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ART XLI.—*Experiments in Cross-Breeding Plants of the same variety;* by Professor W. J. BEAL.

EARLY in the spring of 1877, the writer received the first review of Darwin's book on "The Effects of Cross and Self-fertilization of Plants." The book seemed to be a most instructive production, one which has not been excelled in importance to the farmer by any work in this or in any age. But, in the words of the Gardener's Chronicle, "It is certain that these practical results will be a long time filtering into the minds of those who will eventually profit most by them." If the results are so valuable, and if it will take a long time to reach the farmers, this "filtering" process cannot begin too soon, nor be too continuously kept before them. The writer lost no time in trying similar experiments on several of our cultivated plants, as apples, onions, Indian corn and beans.

Experiments with Indian corn.—Yellow dent corn was obtained from two men in different portions of Michigan. In one case the corn had been kept ten years or more on the same farm, and in the other case fifteen years or more on the same farm. In both cases the corn was much alike. The two lots of corn were planted in alternate rows in a plot by itself. The tops of one set of rows were all cut off, thus securing a perfect cross on those stalks. Seed from this cross was saved and planted to compare with corn not so crossed. The yield from the crossed seed exceeded the yield of that not crossed, as one hundred and fifty-three (153) exceeds one hundred (100).

Crossing black wax beans.—There were, as shown in the plat below, eight short rows two feet apart with the plants finally thinned on July 10th, to five plants about fifteen inches apart

in the row. The seed for half the rows (alternating) is called "old stock," and was raised in the garden the previous year from seeds which descended from those raised on the place for nine years or more.

The "crossed stock" was obtained as follows: in 1877, some seeds of the same variety of beans were purchased of James Vick. These were planted in a drill evenly mixed with seeds of the old stock. These grew and looked alike, but the flowers were inter-crossed by bees. Seeds of this crop are termed "crossed stock."

On May 31, 1878, fifteen seeds were planted in each of the eight rows. The plants from the crossed seeds were generally much the largest and as will be seen kept green the longest.

In ten days after planting, seeds of the old stock came up in each row as follows:..... 4, 7, 7, 9=27
In ten days the crossed stock came as follows: 12, 10, 6, 11=39
In seventeen days the old stock came as follows: 7, 11, 10, 10=38
" " " crossed " " " 12, 13, 10, 14=49

On July 22, the pods fit for cooking on each plant numbered as follows. The pods on the two lots of plants were about alike in size.

Old stock	36	1	dead	7	13 = 57		
Crossed stock	dead	0	0	41	0 =		41
Old stock	0	0	8	0	11 = 19		
Crossed stock	6	22	34	0	17 =		79
Old stock	30	0	0	0	0 = 30		
Crossed stock	41	37	21	31	0 =		130
Old stock	0	0	0	0	2 = 2		
Crossed stock	16	29	30	26	2 =		103
			Total old stock		= 108		
			Total crossed stock		= 353		

This variety is greatly raised for the purpose of supplying an early crop of beans to eat pods and all while young. The difference will be seen to be over three to one in favor of the crossed stock.

On August 9, the pods fit for cooking or past that condition were as follows:

Old stock	52	60	dead	43	45 = 200		
Crossed stock	dead	24	16	51	83 =		174
Old stock	38	46	44	71	37 = 236		
Crossed stock	35	52	58	69	62 =		276
Old stock	39	34	30	47	87 = 237		
Crossed stock	63	48	11	66	61 =		249
Old stock	38	46	54	33	39 = 210		
Crossed stock	38	90	52	88	81 =		340
			Total old stock		= 883		
			Total crossed stock		= 1048		

On or before September 16, all were harvested. The pods on each plant numbered as follows:

Old stock	60	62	dead	45	39 =	206	
Crossed stock	dead	160	54	29	139 =		382
Old stock	45	48	36*	71	37 =	237	
Crossed stock	36	145	91	72	51 =		395
Old stock	45	35	37	38	35† =	190	
Crossed stock	103	68	55	128	75 =		429
Old stock	30	39	48	28	40 =	185	
Crossed stock	136	159	58	172	128 =		653
			Total old stock		=	818	
			Total cross stock		=	1859	

On comparing the table for August 9th, with that for September 16, it will be seen that some plants of the old stock had lost part of their fruit. This was on account of the decay of 101 pods. The table also shows that two branches were broken and had died before maturing. These contained 73 pods.

Adding 101 and 73 to 818, we have 992 pods of the old, against 1859 of the crossed. In harvesting, all those pods badly damaged were rejected. The beans of the old stock weighed 29·77 ounces avoirdupois, those of the crossed stock weighed 70·33 ounces avoirdupois, or nearly in the proportion of 100 to 236.

The difference would be a little less, if we allow for the broken plants and decayed pods on the old stock. One plant of the old and one plant of the crossed stock died early and produced no fruit.

Six lots of 50 beans each, were taken at random from the old stock and weighed as follows:

50 seeds 281 grains.	50 seeds 260 grains.
50 seeds 262 grains.	50 seeds 259 grains.
50 seeds 270 grains.	50 seeds 284 grains.
Total, 1,616 grains.	Average, 269⅔ grains.

The same number of seeds were taken from the crossed stock and weighed as follows:

50 seeds 220 grains.	50 seeds 210 grains.
50 seeds 219 grains.	50 seeds 210 grains.
50 seeds 200 grains.	50 seeds 220 grains.
Total, 1,279 grains.	Average, 213¼ grains.

The average weights of an equal number of beans from each stock were nearly as 100 to 79 in favor of the *old* stock.

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* This plant contained a dead branch with 21 immature pods.
† This plant contained a dead branch with 52 immature pods.

[ART. XLII.—*On the Force of Effective Molecular Action;* by Professor W. A. NORTON.

[An abstract of this paper was read before the National Academy of Sciences, April 18, 1878.]

IN my paper on the variability of the ultimate molecule, published in the March number of this Journal, I gave the following theoretical expression for the force of effective action of one ultimate molecule of a body on another contiguous to it, deduced from certain fundamental conceptions which were succinctly stated:

$$F=\frac{n(3r^2+2rx)}{(r+x)^2(2r+x)^2}-\frac{m}{x^2}, \tag{1}$$

in which x denotes the distance between the electric envelopes of the contiguous molecules; r the distance between the center of emanation of the attractive force, f, represented by the first term, and that of the repulsion f', represented by the second term; n the coefficient of the attraction f, and m that of the repulsion f'. The expression has been simplified by making one or two assumptions that do not strictly accord with fact, but which can occasion no material error in the general discussion now proposed; as will be shown on another occasion.

If we put $x=ur$, $\frac{n}{m}=k$, and $\frac{m}{r^2}=p$, it becomes

$$F=\left(\frac{k(3+2u)}{(1+u)^2(2+u)^2}-\frac{1}{u^2}\right)p. \tag{2}$$

If this be a true theoretical expression for the force of effective molecular action, it should comprise the essential mechanical theory of solids, liquids, and gases, as well as the special mechanical features of individual substances; and should successfully withstand all the quantitative and qualitative tests that can be applied to it. I propose now to give the result of the application of a number of such tests; and to show that the characteristic features and laws of the three different states of aggregation are deducible from it.

Theory indicates that in the comparison of different solids, liquids, or gases, among themselves, at the same temperature, $p\left(=\frac{m}{r^2}\right)$ may be regarded as constant. In fact we shall for the present assume that both m and r, as well as p, are constant for substances in the same state of aggregation, when the temperature is the same. Upon this assumption one substance will differ from another, in its essential molecular condition, only in the value of k, that is of the ratio $\frac{n}{m}$ of the coefficients of the

attractive and repulsive forces f and f'. I have made a series of calculations of the values of F for various assigned values of x, answering to a number of different values attributed to k. Each set of calculations, if graphically represented, will give a curve that may be termed a *curve of effective molecular action*. It will represent to the eye the essential mechanical features of a body for which the assumed value of k obtains.

1.

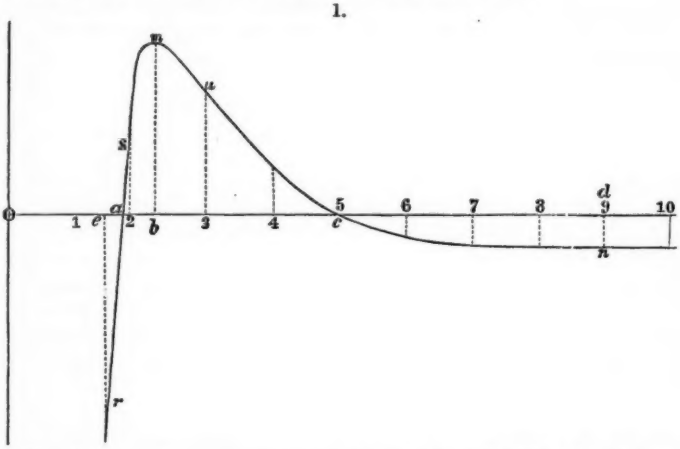
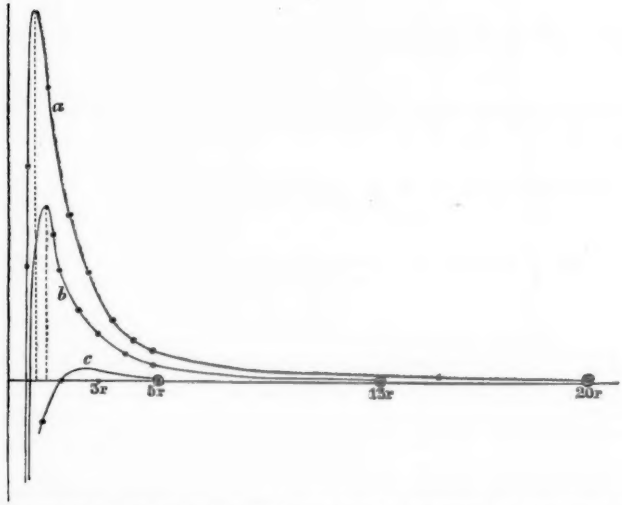


Fig. 1 is such a curve answering to $k = 5{\cdot}428$. In Fig. 2, curve *c*, the same curve is shown on a smaller scale (both horizontal and vertical). Curve *a* in this figure answers to $k = 12{\cdot}41$, and curve *b* answers to $k = 9{\cdot}44$. Fig. 1 may be taken as a type curve exhibiting the features common to the special curves. The positive ordinates indicate comparative values of an effective attractive force in multiples of p, answering to certain distances x expressed in multiples of r; and the negative ordinates indicate values of an effective repulsive force obtaining at other distances x. The distance Oa, between molecular envelopes, at which the effective force is zero, is that which obtains when no external force of stress is in operation. It may be called the *neutral distance*. At all less distances, x, as Oe, that may supervene when a compressive stress is applied to the body, the effective force, er, is repulsive. When a tensile stress is in operation, increasing the distance x, the effective force, as $2s$, becomes attractive, and increases in intensity to the maximum value bm, at the moment of rupture. At greater distances, as $O3$, the effective attraction falls off; and passes into a repulsion when the distance becomes greater than Oc. This repulsion increases with the distance to a maximum dn, and then diminishes continually to an indefinite dis-

tance. This effective repulsion, operating beyond the sphere of the effective attraction, manifests itself as a force of resistance in the contact of bodies. A glance at the curves, (*a*), (*b*), (*c*) in fig. 2, will show that the neutral distance, *Oa*, (see type curve, fig. 1), and the distance, *Ob*, answering to the maximum attractive ordinate, diminish, in multiples of r, as k increases; and that on the other hand, *Oc* and *Od* increase as k increases. The maximum attractive ordinate increases, in terms of p, as k increases, but the maximum repulsive ordinate augments as k diminishes.

2.



The special calculations I have made answer to various assumed values of the ratio k, ranging from 0 to 20. I find that when this ratio exceeds 4·934, the effective force will be attractive over a certain range of distance, and thus that a portion of the representative curve will lie above the axis x, as in the curves shown in fig. 2; and that when this ratio is less than 4·934, the effective action will be repulsive at all molecular distances, and therefore that the curve will lie wholly below the axis, x, as in fig. 3. We must, therefore, conclude that for all solids and liquids, k must exceed 4·934.

The absorption of the pulses of heat by the molecular envelopes of a body tends to expand these envelopes, and at the same time to augment the coefficient of repulsion, m. Heat, therefore, tends to diminish the ratio k, and so to depress the curve of effective molecular action. When by the continued access of heat, this ratio is brought to a certain small value

somewhat greater than 4·934, the molecules are in general brought into a certain condition answering to the liquid state, and liquefaction ensues. When, by a still further rise of temperature k equals 4·934, the liquid has reached the boiling point in vacuo. The curve of effective molecular action is now that shown in fig. 3 for $k=4·93$, and the distance between the molecular envelopes, is 2·84 r.

All special curves, answering to particular solids or liquids, and so to values of k greater than 4·934, have certain common features, which should correspond to properties that have been recognized as belonging to all substances in the solid or liquid state. (1.) One of these is that the curves differ little from a right line at the neutral point a (fig. 1). This corresponds, graphically, to the well known law of molecular displacement, that the effective resistance developed is, for small displacements, porportional to the displacement. The ratio of the effective force $2s$, to the displacement $a2$, may be taken as the measure of the coefficient of elasticity, in considering the comparative values of this coefficient answering to varying amounts of tensile stress, and so to various degrees of molecular displacement. As it appears that this ratio is nearly constant, within small limits, the coefficient of elasticity as experimentally determined, should be nearly constant within such limits; which is a well-known general fact.

(2.) An examination of the curves will serve to show—what is a conspicuous result of the discussion of the equation—that as the tensile stress increases, the coefficient of elasticity as measured by the ratio just stated, should diminish slowly at first and then more rapidly. Experiment has established that in general the coefficient of elasticity of a material varies after this manner. But to make the test more decisive, I have made a series of detailed comparisons of the theoretical with experimental results. It appears that for all values of k ranging from 7·576 to 20 (which, as will hereafter appear, may be regarded as including all the more tenacious solids) the law of variation of the molecular ratio, $\frac{s2}{a2}$ (fig. 1); from the point a to m (i. e. from zero of stress to the point of rupture) is sensibly the same. Thus at the point m, answering to rupture, this ratio becomes reduced to 0·303 of its value at the neutral point, a, when $k=20$; to 0·301 when $k=12·41$; and to 0·316, when $k=7·576$; and the correspondence is equally close at points intermediate between a and m. I have computed the comparative values of the ratio $\frac{s2}{a2}$, for eighteen supposed values of the displacement, $a2$, and compared this scale of computed values,—which, as we have just seen, should answer to any

of the more tenacious materials—with a corresponding series of experimental values of the coefficient of elasticity for bars of cast iron, wrought iron, steel and oak; with the following results. For a bar of cast iron, experimented on by Captain Rodman (U. S. Army), the correspondence is very close. The greatest ratio of error does not exceed $\frac{1}{12}$. For five bars of wrought iron taken for comparison, the correspondence proves tolerably close up to a stress equal to half the tenacity; but at the higher ratios of stress, the coefficient of elasticity diminishes much more rapidly than the theory calls for. For the cast steel bar taken, the coefficient of elasticity is greater than at the neutral point and materially greater than the corresponding molecular ratio, until near the point of rupture, where the two become nearly equal ($\frac{3}{10}$). Several bars of oak examined proved to be in the same category with the cast steel, except that the coefficient ratio at the point of rupture was reduced to from $\frac{6}{10}$ to $\frac{9}{10}$ instead of $\frac{3}{10}$. Four bars of blister steel examined present a case just the reverse of that of the cast steel bar; the coefficient ratios are at all stresses less than the corresponding molecular ratios. In the cases cited the correspondences between the theoretical and the experimental results are sufficient to lend support to the theory; but the discrepancies noticed can only be reconciled with it by admitting that some modifying causes are in operation which tend to produce abnormal deviations from the theoretical results obtained from our formula. Now, as a matter of fact, such modifying causes are known to exist. We have already seen that the ultimate molecule is variable both in its dimensions and its forces, under the operation of varying forces of stress; that k is liable to variation, and hence that the values of F for the same values of x may change, and the molecular curve shift its position and rise or fall according as k increases under the stress or diminishes. As for the actual tendency of a tensile stress, it is immediately to draw the molecular envelopes farther away from their central atoms. It should thus enlarge the effective molecules, and so by increasing the distance between their centers tend to diminish the coefficient of elasticity. But the enlargement of the envelopes should also tend to alter the value of n; and it appears, on a careful investigation of the diverse possible mechanical conditions of the envelopes, that n may either be increased or diminished, and so the value of k become either greater or less. These incidental effects of forces of stress are adequate to the production of all the deviations, under consideration, from the normal molecular condition represented by the formula or by an unvarying curve; except the very large deviations noticed in the case of the wrought iron bars, when the stress amounted to a large fraction of the breaking weight, which may be reasonably ascribed to a flow of the molecules.

(3.) The distance *ab*, (fig. 1) between the neutral point and the point of rupture increases from $0{\cdot}302r$ for $k=20$, to $0{\cdot}60r$ for $k=5{\cdot}428$. This is about its maximum value. From this value of k to the ratio $4{\cdot}934$ it decreases from $0{\cdot}60r$ to zero. Now r is the distance between the centers of attraction and repulsion, both of which lie within the molecular envelope. It is therefore a small fraction of the radius of the outer surface of the envelope, or outer surface of the effective molecule, and a much smaller fraction of the distance between the centers of contiguous molecules. We should then expect, on theoretical grounds, that when a bar suffers rupture under a tensile stress, the elongation would be a small fraction of its length. This is well known to be generally true for the more tenacious materials (e. g. the metals and different varieties of wood). India rubber is a striking exception. Its great extensibility is probably due to a great expansibility of its molecular envelopes, under a tensile stress. The unequal extensibility of different qualities of wrought iron, also finds its theoretical explanation in an unequal expansibility of molecular envelopes, with the attendant variations in the molecular curve.

(4.) The ordinates of the portion *ra* of the molecular curve represent the molecular resistance developed by a compressive stress. These increase (as they should do) without limit, as the distance *Oe* between the molecules diminishes. When rupture occurs under a compressive stress, it is because the molecular actions developed in directions oblique to the line of thrust induce a tensile strain at right angles to this line, and a shearing strain in oblique directions, the resistance to one or the other of which is overcome. The distance *Oa* is not the limit to the possible diminution in the distance between the centers of contiguous molecules, since the act of compression will compress their envelopes, and so diminish the size of the effective molecules.

(5.) The ordinates of the portion *mc* of the molecular curve represent the effective attractions that come into operation during the act of rupture. That the rupture may be completed, a continued molecular strain must be exerted at least as great at each distance of separation, *O*3, as the effective resistance represented by the ordinate 3*u* at that distance. When the distance has increased to *Oc*, an effective repulsion supervenes, and the separation becomes complete.

Beyond *d* the curve represents the force of contact resistance. To test this portion of the curve, I undertook in 1876, to determine experimentally the laws of variation of this force. For this purpose the diminutions of contact distance produced by varying increments of pressure, under varying conditions with regard to the nature, condition, and extent of the surfaces

in contact, were determined. The following are the general results obtained.*

(1.) The diminutions of contact distance are very nearly the same, for the same increments of pressure, whatever is the nature or condition of the surfaces in contact.

(2.) They are very nearly independent of the extent of the surface of contact.

(3.) The diminution of distance for a given increment of pressure (say 1 oz.), is nearly inversely proportional to the pressure.

Now, in correspondence with the first of these laws, it appears that at considerable distances beyond that, Od (fig. 1) of the maximum repulsion the curves answering to different values of k, and therefore to different materials, approach very near to each other, and beyond $100r$ are very nearly coincident, and have nearly the same inclination to the axis of x. This results from the fact that the attractive term in the formula for the effective force becomes at such distances very small, in comparison with the repulsive term which has the same value for different materials when the temperature is the same. To the same small diminution of distance should then correspond very nearly the same increment of the repulsive ordinate, for the molecular curve of each substance.

The second law follows as a consequence from the third.

As for the third law, it is to be observed that at the contact distances that obtained in the experiments, which must have been much greater than that, Od, answering to the maximum repulsive ordinate dn, the first term in equation (1), (p. 346) nearly vanishes, and so the effective repulsion (R) expressed by $R=\frac{m}{x^3}$, is nearly inversely proportional to the square of x. Theoretically then, the diminution of distance (dx) for small increments of the repulsion (dR) should be inversely proportional to $R^{\frac{3}{2}}$, or nearly so, instead of inversely proportional to R, as experiment showed. Here, as in previous cases, the discrepancy may reasonably be attributed to the compression of molecular envelopes that must attend the contact pressure; since such compression should increase the value of k, bring the repulsive portion cn, etc., (fig. 1) of the curve of effective molecular action nearer the axis Ocd, and so cause dx to decrease according to a less rapid law than would obtain if k and the corresponding curve remained constantly the same (which is represented by $\frac{1}{R^{\frac{3}{2}}}$.) In confirmation of this explanation it may be added that a change in the mechanical condition of the contact molecules,

* See this Journal, June, 1876.

during contact pressure, correspondent to this theoretical interpretation, was directly revealed by the experiments.

The experiments alluded to, besides revealing the laws of variation of the contact repulsion, showed that it was a force in operation beyond the range, Oc, of the effective molecular attraction, since no evidence of an attraction was obtained. They showed also that the increments of this force, attendant on the observed diminutions of molecular distance, were many times less than the increments of repulsion attendant on equal diminutions in the distance between the internal molecules of a body; in accordance with the indications of the molecular curve.

It will probably occur to the reader that our formula and curve of effective molecular action, afford no indication of a possible force of adhesive attraction, such as often manifests itself in the contact of surfaces. This defect results from the fact that the formula involves a supposition which is not strictly true in cases of contact. The more comprehensive formula is:

$$f=\frac{n}{(r+x)^2}-\frac{n'}{(2r+x)^2}-\frac{m}{x^2};$$

and equation (1) is obtained by supposing $n'=n$. This equality may not strictly exist in the contact of bodies, and n' may be less than n. I find that a slight excess of n above n' suffices to give an effective attraction for a certain range of values of x, for which f is repulsive according to equation (1). This case would be graphically represented by an upward inflection of the repulsive portion of the curve (fig. 1), bringing a portion of it above the axis of x. The attraction thus orginating should vary in its intensity at a given distance with the pressure, or molecular distance at contact, (i. e. graphically, the inflection of the curve should change); and recent experiments have shown this to be an essential feature of it, since it appears that pieces of plate glass in contact may be separated by the continuous exertion of a force ever so small.

I have now examined the general features of the typical molecular curve for solids, and shown that they represent diverse general mechanical properties of solids that have been experimentally ascertained. Let us now endeavor to subject the molecular formula (equation 2) to the test of comparison with experimental determinations of the coefficients of elasticity and tenacities of special substances. The direct means of accomplishing this would be to determine, if possible, the value of the ratio k for each material, and so obtain a series of definite expressions, or corresponding molecular curves, answering to the materials considered. But the value of k for a given substance is, from the nature of the case, incapable of direct deter-

mination. The only practicable method of proceeding is to assume, under the guidance of any intimations that may be obtained, a value of k for some substance, say wrought iron, taken as a standard of comparison; then the ratio which the coefficient of elasticity of any other material bears to that of wrought iron, will make known the value of its molecular ratio $\frac{2s}{a2}$ (fig. 1) at the neutral point, as compared with that of iron, and from this we may derive the comparative molecular curve for the material considered. The ratio of the maximum ordinate of this curve to that of the standard curve for wrought iron, will then make known the ratio of the tenacity of the material to that of wrought iron (account being taken of the comparative number of atoms, or ultimate molecules, of the two materials, in a unit of volume) and so enable us to compute theoretically its tenacity from the known tenacity of wrought iron. This computed value may then be compared with the tenacity as experimentally determined. In the prosecution of this inquiry, I assumed as the value of k for wrought iron, 12·41; taking for the coefficient of elasticity (E) 25,000,000 lbs., and for the tenacity 55,000 lbs. per square inch. The molecular curve for wrought iron would then be that shown in fig. 2, curve (a). The following notation and formulas were used in the calculations: N=number of atoms, or ultimate molecules in a unit of volume=$\frac{\text{specific gravity}}{\text{atomic weight.}}$; n=number of atoms (ultimate molecules) in unit of length $=\sqrt[3]{N}$; E= coefficient of elasticity; T=tenacity; f=intensity of effective attraction between two contiguous molecules at the neutral distance, developed by an increment of distance, equal to $\frac{1}{1000}r$. This, in fig. 1, is represented by the ordinate $2s$ corresponding to the small displacement $a2$. F=max. ordinate of the molecular curve. c, c', and c'' are constants.

$$E=c\frac{fn^3}{n}=cfn. \quad T=c'Fn^2.$$

Neutral distance, $d=\frac{r}{\log(1+100f)+u}$; in which u may be taken =zero for the metals generally and the more tenacious woods, for which k must have a value not widely different from that taken for wrought iron (12·41). For less tenacious materials u has a value increasing as k diminishes. For k= 7·576, its value is 0·05. Its maximum value is $\frac{1}{2\cdot84}$, and obtains when f=o, in which case k=4·934, and the molecular curve falls entirely below the axis x. f is expressed in terms of $\frac{m}{r^2}$ or p, considered as unity (see page 346). For the more

tenacious materials we may take, with but little error, $d=\frac{r}{\log 100f}$.

For calculating the maximum ordinate we have the formula, $F=\frac{c^u}{d^{3\cdot 2}}$.* With these formulæ I have calculated the theoretical tenacities of a number of materials. The results are given in the following table, and compared with the tenacities obtained by experiment. With most of the materials the experimental determinations of coefficients of elasticity and tenacity used, are known, or there is good reason to believe, answer to the same specimen; but in the cases of zinc, brass, and tin, the coefficient of elasticity and the tenacity may have been obtained with different specimens.

Material.	Coeff. of Elas., E.	Tenacity.	
		Observed.	Calculated.
Wrought Iron	25,000,000 lbs.	55,000 lbs.	
Teak	2,214,000 "	15,000 "	14,600 lbs.
Locust	1,795,000 "	11,280 "	11,157 "
Oak	1,311,100 "	8,500 "	8,170 "
Scotch Fir	802,800 "	3,520 "	3,586 "
Copper	16,447,400 "	36,180 "	36,460 "
Zinc Wire	13,680,000 "	22,551 "	27,950 "
Brass, cast	9,170,000 "	18,000 "	20,300 "
Tin, cast	4,608,000 "	6,650 "	7,820 "
Lead	720,000 "	1,824 "	1,870 "

It seems from these results that our molecular formula (equation 2) enables us to compute the comparative tenacities of materials from their comparative coefficients of elasticity, with a close approximation to the truth; also that a scale of molecular curves may be deduced from it which serves to represent the comparative mechanical properties of different materials. The scale obtained rests on the assumption that the molecular curve for wrought iron is that answering to $k=12{\cdot}41$ (fig. 2) curve (a). But the laws of variation of the neutral distance, d, and the maximum ordinate, F, are so nearly constant over a wide range of variation in the value of k, and thus of the corresponding molecular curve, that the assumed curve for wrought iron might be considerably changed without materially impairing the correspondence between the computed and observed tenacities. The exponent of d in the expression for the maximum ordinate, which in the calculations was taken $3{\cdot}2$, varies only from $3{\cdot}1$ to $3{\cdot}4$ over the entire range of values of k from 20 to $5{\cdot}4$; and the value of u in the expres-

* Each molecule is subject to the action of several molecules, instead of the nearest one only, but the entire force taking effect on it is equal to the effective action of the nearest molecule multiplied by a factor which should be nearly constant for different materials.

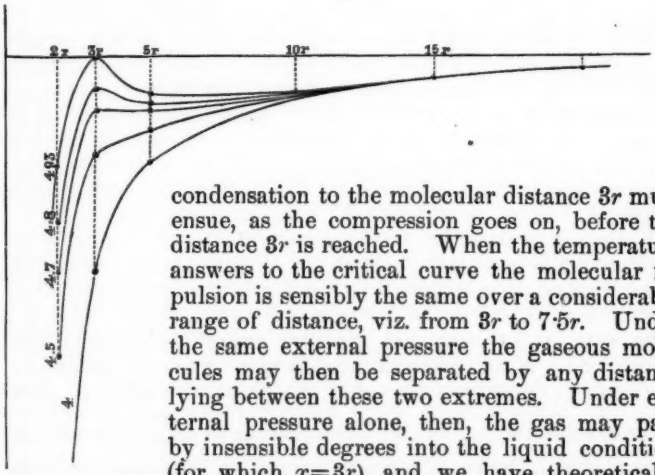
sion for the neutral distance varies only from zero to less than $\frac{1}{3}$.

It is important to remark, in this connection, that the complete molecular theory of the elastic resistance of materials cannot be developed from the single conception that each specimen of every material has its specific formula, or curve of effective molecular action, which remains constantly the same during all the varying conditions and degrees of stress. Thus when two specimens of the same material are compared, certain facts are recognized which require that account should be taken of the varying dimensions and mechanical condition of the molecules when under the influence of the force of stress. For example, the tenacities of two bars of wrought iron, or one bar of iron and another of steel, may be very different, though their coefficients of elasticity, E, may be nearly the same. The theoretical explanation of this fact, is that the molecular envelopes are drawn farther away from the central atoms of the molecules, and as a consequence the ratio k is increased, the molecular curve rises, and thus while the coefficient, E, for small displacements from the neutral distance is but little altered, the maximum ordinate, and so the tenacity, may be largely increased. It may be shown that the liability to this state of things exists with materials having a high value of k. The rise of the "limit of elasticity" as the result of the operation of a tensile stress to certain materials, and the augmentation of the tenacity of wrought iron bars by large tensile strains, as well as by a certain increase of temperature and by the process of thermo-tension, are other consequences of a similar molecular condition. It may be said in general that all the recognized deviations of property from the normal type of unvarying and perfect elasticity, while they must present insuperable obstacles to any molecular theory that does not recognize the "variability of the ultimate molecule," furnish to the present theory the occasion of its achieving one of its most signal triumphs.

Let us now subject the formula to the test of comparison with the laws and mechanical properties of vapors and gases. Upon the general theory the effective mutual actions of contiguous molecules of a vapor, or gas, must be repulsive. The curve of effective action of such a molecule must then lie entirely below the axis x; and hence it must answer to a value of k less than 4·934. Fig. 3 shows a set of theoretical curves answering to various values of k in equation 2, from 4·93 to 4. The vertical scale in this figure is 20 times that in fig. 2. These curves present two distinct varieties; one in which a portion of the curve is concave to the axis, x, and another in which the curve is everywhere

convex to this axis. These two sets of curves have for their line of demarcation a curve in which a considerable portion is parallel to the axis. This curve answers to $k=4{\cdot}7$. The first or upper set of curves answers to vapors, and to gases when their temperature is such that they can be compressed into a liquid without further reduction of temperature. The reduction to a liquid by pressure alone is possible with some gases, (as sulphurous acid gas, chlorine, carbonic acid, etc.) at ordinary temperatures, and continuously up to certain higher temperatures. At these critical temperatures the curve becomes the critical curve just mentioned for which $k=4{\cdot}7$. Oxygen, hydrogen, etc., belong to a class of gases which cannot be condensed into a liquid unless the temperature is much reduced below ordinary temperatures. For these the smaller values of k obtain. The condensation into the liquid form is impossible because the repulsive ordinate steadily increases as the molecular distance x diminishes. A reduction of temperature diminishes the value of m, which is theoretically proportional to the absolute temperature, and so increases the value of k and causes the molecular curve to rise. When it is thus brought above the critical curve, for which $k=4{\cdot}7$, it becomes for a certain distance beyond $3r$ concave upwards, the effective repulsion begins to decrease at a certain distance beyond $3r$, and a sudden

3.



condensation to the molecular distance $3r$ must ensue, as the compression goes on, before the distance $3r$ is reached. When the temperature answers to the critical curve the molecular repulsion is sensibly the same over a considerable range of distance, viz. from $3r$ to $7{\cdot}5r$. Under the same external pressure the gaseous molecules may then be separated by any distance lying between these two extremes. Under external pressure alone, then, the gas may pass by insensible degrees into the liquid condition (for which $x=3r$), and we have theoretically the "continuity between the gaseous and liquid states of matter," experimentally realized by Dr. Andrews. The critical temperature for carbonic acid gas, Dr. Andrews found

to be 31° C. At this temperature then the molecular curve for this gas was the curve for which $k=4{\cdot}7$.

We have already seen that when a liquid reaches its boiling point in vacuo, its molecular curve is just tangent to the axis, x, at the point $x=2{\cdot}84r$, and that $k=4{\cdot}934$. When the liquid, say water, is subject to the atmospheric pressure, as the temperature rises above 72° F., (its boiling point in vacuo) and m continually increases, the curve subsides until the molecular repulsion, for $x=3r$, is just on the point of prevailing over the atmospheric pressure. The liquid will then be at its boiling point, 212° F. The slightest increase of heat repulsion will now cause the molecules to recede from each other, since the effective repulsive ordinates augment with the distance, x, and this recess should continue until the repulsive ordinate again becomes equal to the minimum value, that obtained when the recess began. To this tendency to a sudden separation of the molecules over a wide range of distance may be ascribed the agitation of the liquid, called boiling; and the amount of the final separation should fix the ratio of expansion in the passage of the liquid into vapor, at the boiling point. If the liquid boils under a higher pressure than one atmosphere, the access of heat augments the minimum molecular repulsion that obtains at about the distance $3r$, until it is on the point of prevailing over the actual pressure. The curve will now have subsided still more, and the recess of the molecules to the point at which the molecular repulsion becomes the same again, and so the expansion from the liquid to the steam at the higher boiling point and pressure, should be less than before (see fig. 3). It should be observed here, that the process of expansion in the conversion of the liquid into steam consists in part in an expansion of the molecular envelopes, or an enlargement of the effective molecules; and part of the heat lost is expended in thus augmenting the potential energy of the molecules.

When the reverse process occurs, and steam at 212° F. is condensed, the increasing repulsion shown by the curve is largely expended in condensing the molecular envelopes, with an attendant evolution of heat; and thus the process may set in as soon as the external pressure materially exceeds one atmosphere. A reduction of temperature brings on condensation by decreasing the value of m, which has the effect to raise the molecular curve, both by diminishing $p\left(=\frac{m}{r^2}\right)$ the unit in terms of which the repulsions are expressed, and increasing the ratio $k\left(=\frac{n}{m}\right)$.

[To be continued.]

ART. XLIII.—*On the Mineral Locality in Fairfield County, Connecticut, with the description of two additional new species;* by GEORGE J. BRUSH and EDWARD S. DANA. Second paper.

IN the preceding volume of this Journal (July and August, 1878), we published an account of the discovery of a new mineral locality at Branchville, Fairfield County, Connecticut, and gave descriptions of five new minerals, all manganesian phosphates, occurring there. During the autumn following we pushed forward our explorations at the locality with as much vigor as possible, and with tolerable success. We were fortunate in finding a new and independent deposit of the phosphates, and obtained from it a considerable quantity of eosphorite, lithiophilite and a little triploidite, and with them some other species of interest, among which we may mention a series of uranium compounds. The detailed description of these discoveries we shall defer until a third paper, which we hope to publish in another number. In the present paper we propose to give the descriptions of the two additional new species we have identified; one of these we mentioned in our last paper under the name of *fairfieldite.* We add also the results of a new analysis of reddingite, and some further facts in regard to lithiophilite. Both of the new species came from the original material, removed by Mr. Fillow, when the locality was first opened. We have not, as yet, succeeded in finding additional quantities of them. It may not be improper to add that with the return of warm weather we have commenced anew the exploration of the locality in a more thorough manner than before, and we hope to meet with some success.

6. FAIRFIELDITE.

General physical characters.—Fairfieldite occurs usually in massive crystalline aggregates; also rarely in distinct crystals. The structure is foliated to lamellar, some varieties closely resembling selenite; also occasionally in radiating masses consisting of curved foliated or fibrous aggregations; these radiated forms are not unlike stilbite.

The hardness is 3·5, and the specific gravity 3·15. The luster is pearly to sub-adamantine; on the surface of perfect cleavage (*b*) it is highly brilliant. The color is white to pale straw-yellow; the streak is white. Transparent. Brittle.

Two rather distinct varieties have been observed: the first (A) occurs filling cavities in the reddingite, and covering the distinct crystals of this mineral. It is uniformly clear and transparent, and is highly lustrous, showing entire absence of even

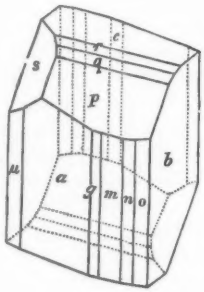
incipient alteration. It is generally foliated to lamellar, although sometimes of a somewhat radiated structure. The second variety (B) occurs in masses of considerable size interpenetrated rather irregularly with quartz, and quite uniformly run through with thin seams and lines of a black manganesian mineral of not very clearly defined character. This mineral is granular in texture, lustrous, is difficultly fusible, and consists for the most part of the hydrated oxides of manganese and iron; but contains also phosphoric acid and traces of lime.

This second variety of fairfieldite is often friable to the touch and lacks something of the brilliant luster of the first variety. It also shows greater difference of structure, passing from the distinct crystals to the massive and radiated form. The identity of these two kinds is shown by the analyses given below. Fairfieldite also occurs in small particles in fillowite (described beyond), and in masses of some size immediately associated with eosphorite, triploidite, and dickinsonite.

Crystalline form.—Indistinct crystals of fairfieldite occur occasionally in cavities in the massive mineral. They are usually composite in character, made up of many individual crystals, interpenetrating each other, and in only an approximately parallel position. On the most favorable crystals the form could be clearly made out, but exact measurements were quite impossible; this is the more to be regretted as the number of variable elements is so large. The cleavage parallel to b (010) is highly perfect; that parallel to a (100) somewhat less so.

The crystals belong to the *Triclinic System*, and the general habit is shown in the adjoining figure. The following supplement angles were accepted as the basis of the calculations.

$a \wedge c$	$100 \wedge 001$	=	88°
$a \wedge b$	$100 \wedge 010$	=	102°
$a \wedge p$	$100 \wedge 111$	=	56° 30′
$c \wedge p$	$001 \wedge 111$	=	33°
$b \wedge p_1'$	$010 \wedge 111$	=	78° 30′



From these angles, the lengths and mutual inclinations of the axes were calculated, as follows:—

	c (vert.)	$\bar{b}$	$\breve{a}$
	·7065	3·5757	1·0000 or
	·1976	1·0000	·2797
Also	$\alpha\ (c \wedge \bar{b})$	$\beta\ (c \wedge \breve{a})$	$\gamma\ (\bar{b} \wedge \breve{a})$
	102° 9′	94° 33′	77° 20′

The observed planes are as follows:—

c	*0*	001	*s*	$\breve{4}\text{-}\breve{4}$	$1\bar{4}1$
b	$\breve{1}\text{-}\breve{1}$	010	*g*	$\breve{1}\text{-}\breve{\frac{1}{2}}'$	320
a	$\breve{1}\text{-}\breve{1}$	100	*m*	*I'*	110
p	-1′	111	*n*	$\breve{1}\text{-}\breve{\frac{3}{2}}'$	230
q	$-\frac{1}{2}'$	112	*o*	$\breve{1}\text{-}2'$	120
r	$-\frac{1}{3}'$	113	*μ*	*I*	$1\bar{1}0$

The following list includes the principal angles (supplement) for the different planes, calculated from the axial values given above.

	Calculated.		Measured.
$c \wedge a$	$001 \wedge 100$ =	88°	*88°
$c \wedge b$	$001 \wedge 010$ =	78° 33′	79°
$c \wedge m$	$100 \wedge 110$ =	84° 39′	
$c \wedge p$	$001 \wedge 111$ =	33°	*33°
$c \wedge q$	$001 \wedge 112$ =	18° 31′	19°
$c \wedge r$	$001 \wedge 113$ =	12° 43′	13°
$c \wedge s$	$001 \wedge 1\bar{4}1$ =	53° 34′	
$a \wedge b$	$100 \wedge 110$ =	102°	*102°
$a \wedge g$	$100 \wedge 320$ =	10° 57′	10°
$a \wedge m$	$100 \wedge 110$ =	16° 31′	16° 30′
$a \wedge n$	$100 \wedge 230$ =	24° 40′	25°
$a \wedge o$	$100 \wedge 120$ =	32° 20′	32°
$a \wedge \mu$	$100 \wedge 1\bar{1}0$ =	14° 45′	16°
$a \wedge p$	$100 \wedge 111$ =	56° 30′	*56° 30′
$a \wedge q$	$100 \wedge 112$ =	70° 15′	
$a \wedge r$	$100 \wedge 113$ =	75° 48′	
$a \wedge s$	$100 \wedge 1\bar{4}1$ =	51° 17′	
$b \wedge \mu$	$010 \wedge 1\bar{1}0$ =	116° 45′	
$b \wedge g$	$010 \wedge 320$ =	91° 3′	
$b \wedge m$	$010 \wedge 110$ =	85° 29′	
$b \wedge n$	$010 \wedge 230$ =	77° 20′	
$b \wedge o$	$010 \wedge 120$ =	69° 40′	
$b \wedge p$	$010 \wedge 111$ =	78° 30′	*78° 30′
$b \wedge q$	$010 \wedge 112$ =	78° 2′	78°
$b \wedge r$	$010 \wedge 113$ =	78° 4′	
$b \wedge s$	$010 \wedge 1\bar{4}1$ =	121° 16′	120° 30′
$m \wedge p$	$110 \wedge 111$ =	51° 39′	
$m \wedge q$	$110 \wedge 112$ =	66° 8′	
$m \wedge r$	$110 \wedge 113$ =	71° 56′	

In one case an apparent penetration-twin was observed, the two crystals crossing one another so that the planes *b* and *a* of the one were parallel respectively to the planes *a* and *b* of the other. If this coincidence were perfect (exact measurement was out of the question) and the crystal were really a twin the

twinning-plane must make with a (100) an angle of either 51° (toward 010) or 39° (toward $0\bar{1}0$). This condition is equally well satisfied by the plane 270 ($100 \wedge 270 = 51°\ 4'$), or by $2\bar{7}0$ ($100 \wedge 2\bar{7}0 = 39°\ 3'$.) As this supposed twinning-plane has so complex a relation to the other planes of the crystal, it is probable that this coincidence is only accidental.

Optical properties.—Minute fragments of fairfieldite parallel to the two cleavage planes were examined in the stauroscope, with the following results:—The planes of light-vibration intersect the cleavage plane a (100) in lines which make angles of 40° and 50° respectively with the edge $a \mid b$. One optical axis was visible on the edge of the field in converging light, obviously lying in the vibration-plane making an angle of 50° with the obtuse edge named, and toward that edge.

The cleavage plane parallel to b (100) is intersected by the vibration planes in lines making angles of 10° and 80° respectively with the edge $b \mid a$. In this case also an optical axis (the second) is distinctly visible on the outer limit of the field. This serves to fix approximately the position of the bisectrix. As the cleavage fragments examined were less than $\frac{1}{2}$ mm. in size, any further examination was impossible.

Chemical Composition.—The two varieties of fairfieldite have been analyzed by Mr. S. L. Penfield, with the following results:

	A.	B.
P_2O_5	38·39	39·62
FeO	5·62	7·00
MnO	15·55	12·40
CaO	28·85	30·76
Na_2O	0·73	0·30
K_2O	0·13	----
H_2O	9·98	9·67
Quartz	1·31	0·55
	100·56	100·30

The ratios of the oxides calculated from these analyses are as follows:—

		A.				B.	
P_2O_5	·270	·270	1		·279	·279	1
FeO	·078				·097		
MnO	·219				·175		
CaO	·515	·825	3·06		·549	·826	2·96
Na_2O	·012				·005		
K_2O	·001				---		
H_2O	·554	·554	2·05		·537	·537	1·93

The ratio $P_2O_5 : RO : H_2O = 1 : 3 : 2$ answers to the formula $R_3P_2O_8 + 2$ aq. If here $R = Ca : Mn + Fe = 2 : 1$ and the ratio of Mn : Fe be also 2 : 1. The formula requires:—

P_2O_5	39·30
FeO	6·64
MnO	13·10
CaO	30·99
H_2O	9·97
	100·00

The fact that the second variety was friable and somewhat deficient in luster suggested an incipient alteration, but the analysis did not confirm this idea. The larger amount of lime afforded in the analysis of this kind is possibly due to admixture of a little apatite, which is often observed with it, and the larger proportion of iron may be due to the fact that this variety could not be entirely freed from the black oxide interpenetrating it.

Pyrognostics.—In the closed tube fairfieldite gives off neutral water, and the assay turns first yellow, then dark brown, and becomes magnetic. In the forceps glows, blackens and fuses quietly at about 4·5 to a dark yellowish-brown mass, coloring the flame pale green, with faint reddish-yellow streaks on the upper edge. Soluble in the fluxes giving reactions for iron and manganese. Fairfieldite is soluble in nitric and hydrochloric acids.

Fairfieldite is named from the county in which the locality occurs.

7. Fillowite.

General physical characters. — Fillowite occurs in granular crystalline masses. By fracture the crystalline grains can be usually separated with ease; they show in most cases merely striated planes of contact, having no crystallographic significance; occasionally, however, isolated but brilliant crystalline planes are observed and rarely a nearly complete crystal. The masses are not infrequently penetrated by distinct prismatic crystals of triploidite; and sometimes they enclose particles of fairfieldite. The outer surfaces are very often coated with a silvery-white radiated mineral, but in so sparing quantities that we have been thus far unable to determine definitely its character. Reddingite is very commonly associated with fillowite, and in many cases it is not easy to distinguish the two minerals.

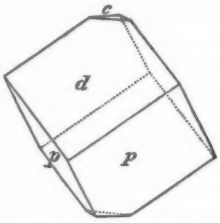
The hardness is 4·5, and the specific gravity in two trials 3·41 and 3·45. The luster is sub-resinous to greasy. The color generally wax-yellow, also yellowish to reddish-brown with a red or green tinge, and rarely almost colorless. Streak white. Transparent to translucent; fracture uneven; brittle.

Crystalline form.—The crystals of fillowite, whose occurrence has already been mentioned, have a marked rhombohedral

aspect. As shown in the figure the three planes, whose several inclinations are almost identical, have their common solid angle replaced by a nearly equilateral triangle. The measurements, however, point to a monoclinic form, and that this is the true explanation is proved by the optical examination. The cleavage is basal, nearly perfect.

The angles (supplement) accepted as the basis for calculation, are as follows:—

$c \wedge p$	$001 \wedge \bar{1}11$	=	58° 40′
$c \wedge d$	$001 \wedge 201$	=	58° 31′
$p \wedge p$	$\bar{1}11 \wedge \bar{1}\bar{1}1$	=	95° 23′



Calculated from these the elements of the crystal are:—

c (vert.)	*b*	*d*	*β*
·8201	·5779	1·0000 or	89° 51′
1·4190	1·000	1·7303	

The position taken for the crystal is that which exhibits most strikingly its close approximation to the rhombohedral form. If it were desired to make the plane *d* the unit orthodome $\bar{1}01$, then the plane *p* would have the symbols 111 and $1\bar{1}1$, and the elements of the crystal would be:— $\beta = 73° 11'$; *c* (vert.) = 1·1422, *b* = 0·578, *d* = 1·000.

The observed planes have already been given; they are:—

c 001 *O.* *d* 201 -2-*i.* *p* $\bar{1}11$ 1.

The calculated angles and those measured (on two crystals) are:—

			Calculated.	Measured. (1)	(2)
$c \wedge d$	$001 \wedge 201$	=	58° 31′	*58° 31′	
$c \wedge p$	$001 \wedge \bar{1}11$	=	58° 40′	*58° 40′	
	$001 \wedge \bar{1}\bar{1}1$			58° 37′	
$p \wedge p$	$\bar{1}11 \wedge \bar{1}\bar{1}1$	=	95° 23′	*95° 23′	95° 25′
$p \wedge d$	$\bar{1}11 \wedge 201$	=	95° 20′	95° 20′	95° 15′
	$\bar{1}\bar{1}1 \wedge 201$			95° 16′	95° 18′

Optical properties.—It was found possible to examine small cleavage fragments of fillowite according to the usual methods, and the results served to settle the question of the system, which the measured angles might have left undecided. One vibration-plane intersects the basal plane (cleavage) parallel to the edge $c|d$ and the other is normal to it. Moreover the two optic axes are visible when the Rosenbusch microscope is employed; it was impossible to decide, however, in which plane they lay, since the only sections transparent enough for this examination were destitute of the other crystalline planes.

Chemical properties.—The analyses of fillowite by Mr. S. L. Penfield afforded the following results:—

	I.	II.	Mean.		Ratios.	
P_2O_5	39·06	39·15	39·10	·275	2·75	1
FeO	9·48	9·18	9·33	·129		
MnO	39·48	39·36	39·42	·555		
CaO	undet.	4·08	4·08	·073	8·51	3·09
Na_2O	5·65	5·84	5·74	·092		
Li_2O	·07	·04	·06	·002		
H_2O	1·75	1·56	1·66	·092	·92	0·33
Quartz	0·86	0·90	0·88			
		100·11	100·27			

The ratio $P_2O_5 : RO : H_2O = 1 : 3 : \frac{1}{3}$, corresponds to the formula $3R_3P_2O_8+H_2O$. If in this formula R = Mn : Fe : Ca : Na_2 = 6 : 1 : 1 : 1 the calculated percentages are:—

P_2O_5	40·19
FeO	6·80
MnO	40·19
CaO	5·28
Na_2O	5·84
H_2O	1·70
	100·00

The very small amount of water present suggests the question as to whether it is really an original constituent of the mineral. This question we have been unable to decide positively; we can only add that of a large number of specimens examined, all, even the most transparent, showed its presence. Moreover, if the water be not essential, the composition of the mineral would be somewhat analogous to triphylite, containing sodium instead of lithium, and the want of correspondence in crystalline form does not favor this idea.

Pyrognostics.—In the closed tube fillowite yields a small amount of water which reacts neutral. B.B. in the forceps colors the flame momentarily pale green, then intensely yellow and fuses with intumescence to a black feebly magnetic globule. Fusibility 1·5. With the fluxes reacts for iron and manganese. Soluble in nitric and hydrochloric acids.

We have named this the *seventh* new manganesian phosphate from this locality, after Mr. A. N. Fillow, of Branchville, Conn., our obligations to whom we have already mentioned in our former paper.

Reddingite.

In our preceding paper we described the new mineral reddingite, and showed that in the habit of its octahedral crystals and in their angles it was closely homœomorphous with scorodite and strengite. In composition, however, it was shown that there was a variation, as follows:—

Scorodite	$FeAs_2O_5+4aq.$
Strengite	$FeP_2O_5+4aq.$
Reddingite	$Mn_3P_2O_8+3aq.$

It is thus seen that reddingite differs from the other species in that the metal is in the protoxide condition, and again since there are only three equivalents of water present. In order to establish beyond all question that this difference was a real one, we have had a second analysis made. The material was selected from another specimen, and as before, was obtained free from all impurities except quartz.

The analyses, made by Mr. H. L. Wells, are given below (A) as also that of Mr. Penfield (B) published in our preceding paper:—

	I.	II.	A Excluding Quartz.	B
P_2O_5	33·58	----	35·16	34·52
FeO	7·54	----	7·89	5·43
MnO	41·28	----	43·22	46·29
CaO	0·67	----	·71	0·78
Na_2O	trace	----	----	0·31
H_2O	11·72	11·72	12·27	13·08
Quartz	4·46	4·39		
	99·25		99·25	100·41

The new analysis leads to the formula $Mn_3P_2O_8+3aq$, or the same as that obtained before. The only marked difference between the two results is one which we have found to characterize all the species of the locality, that is, a little variation in the relative amounts of iron and manganese. That the manganese is really in the protoxide condition cannot be questioned for a moment.

Recapitulation.

It seems of some interest to place together the seven new species which the locality has afforded us. We shall hope, at some future time, to offer some remarks in regard to their mutual relations; we can only say here that there is in the facts observed nothing to suggest that any one of the species is a secondary mineral or a product of alteration; all seem to be original minerals of the vein. We have found single hand-specimens which exhibit all of the first four minerals together.

1. EOSPHORITE.		Orthorhombic.
$R_2AlP_2O_{10}, 4H_2O,$	or	$AlP_2O_5+2H_2Mn(Fe)O_2+2aq.$
2. TRIPLOIDITE.		Monoclinic.
$R_4P_2O_9, H_2O$	or	$Mn_3(Fe_2)P_2O_8+Mn(Fe)(OH)_2$
3. DICKINSONITE.		Monoclinic.
$4(R_2P_2O_8), 3H_2O$	or	$4(Mn, Fe, Ca, Na_2)_3P_2O_8+3aq.$

4. LITHIOPHILITE.		Orthorhombic.
$LiMnPO_4$	or	$Li_3PO_4 + Mn_3P_2O_8$.
5. REDDINGITE.		Orthorhombic.
$R_3P_2O_8$, $3H_2O$	or	$Mn_3(Fe_2)P_2O_8 + 3aq$.
6. FAIRFIELDITE.		Triclinic.
$R_3P_2O_8$, $2H_2O$	or	$Ca_3(Mn_3, Fe_2)P_2O_8 + 2aq$.
7. FILLOWITE.		Monoclinic.
$3(R_3P_2O_8)$, H_2O	or	$3(Mn, Fe, Ca, Na_2)_3P_2O_8 + aq$.

Altered Lithiophilite.

In our former paper we called attention to the large amount of black oxidized material rich in lithia which was associated in the first deposit with eosphorite, triploidite and dickinsonite. We stated also, that the occurrence of this black substance induced us to make the deeper exploration which resulted in the discovery of lithiophilite. We have now made a more critical examination of this black mineral, and have found on breaking it up into very small fragments occasional kernels or nuclei, often no larger than a pea, of unaltered lithiophilite. By far the greater part of the black masses, however, have proved to be oxidized to the core. The black material varies considerably in its structure; some specimens retain with great distinctness the cleavage of the original lithiophilite; other fragments break with a conchoidal fracture, while still other specimens form porous, crumbly, loosely aggregated masses. The color of the mineral also varies; it is generally grayish-black to pitch-black; occasionally, however, it has a purple to violet color, the latter being due apparently to a different state of oxidation of the manganese and iron. That this is the case seems to be proved by the fact that the black variety can be made to assume a purple hue by dipping it in hydrochloric acid; the mass so treated becomes at once colored purple externally, and is not to be distinguished from a specimen of the naturally occurring purple mineral. The luster varies from sub-resinous to dull. Hardness 3–4. Specific gravity 3·26–3·40. It is not to be expected that in such an alteration product the chemical composition should be constant. We have had two characteristic specimens analyzed and give the results below. The first was of the cleavable variety, having a nucleus of unaltered lithiophilite, and was analyzed by Mr. F. P. Dewey, in the Sheffield Laboratory, G.=3·39–3·40.

	I.	II.	Mean.		Atomic Ratios
P_2O_5	40·79	40·53	40·66		·286
Fe_2O_3	12·55	12·57	12·56		·079
Al_2O_3	0·10	0·09	0·10		·001
MnO	35·83	35·66	35·74	Mn_2O_3 25·27	·160
O in excess	1·20	1·18	1·19	= MnO 11·66	·164
CaO	0·13	0·23	0·18		·003
MgO	*tr.*	*tr.*	*tr.*		
Li_2O	5·71	5·61	5·66		·188
Na_2O	0·44	0·53	0·49		·008
H_2O	3·11	3·03	3·07		·170
	99·86	99·43	99·65		

Another specimen of the more compact dull variety analyzed by H. L. Wells, afforded the following results:—G. = 3·26–3·27.

	I.	II.	Mean.		Atomic ratio.		
P_2O_5	40·25	40·51	40·38		·284		1
Fe_2O_3	16·04	15·74	15·89		·099	·191	
MnO	32·07	31·99	32·03	Mn_2O_3 14·71	·092		
O in excess	1·47	1·50	1·48	= MnO 18·80	·265		
CaO	·74	·70	·72		·010	·339	2·88
Li_2O	4·69	4·96	4·83		·161		
K_2O	0·25	0·28	0·26		·003		
Na_2O	*tr.*	*tr.*	*tr.*				
H_2O	3·32	3·41	3·37		·187		
Residue	0·90	0·90	·90			·187	
			99·86				

This last variety approaches the composition of a normal phosphate, but as before remarked it is not to be expected that such products of alteration should be homogeneous or prove to be definite mineral species. In general the above analyses show a marked correspondence with the analogous product of the alteration of the Norwich triphilite as analyzed by Craw and Mallet. The Branchville black material is, however, richer in manganese and in lithia, and fortunately we find it enveloping unaltered lithiophilite so that there can be no question as to the character of the original mineral.

In order to avoid any misunderstanding we may repeat here a remark already made, that we have observed also a variety of other black decomposition products bearing no relation to the above. One of them contains the oxides of iron and manganese simply being derived from the alteration of the carbonate (rhodochrosite); others have been derived respectively from the decomposition of eosphorite, triploidite and reddingite. The last named has often the characteristic octahedral form of the original mineral.

We would express here our sincere thanks to the three gentlemen, Messrs. Penfield, Wells and Dewey, who have assisted us in the chemical part of this investigation.

ART. XLIV.—*Note on the Fox Hills Group of Colorado;* by J. J. STEVENSON, Professor of Geology in the University of New York.

NOT far from thirty miles below (north) Denver, St. Vrain's Creek enters the South Platte River from the west. The Thompson enters from the same side several miles above Evans, or about forty-five miles below Denver; and the Cache La Poudre, in like manner, enters somewhat more than fifty miles from Denver. The towns of Evans and Greeley lie close together, the former being on the South Platte River almost fifty miles from Denver.

In 1873, I visited this region and made some observations, which were published shortly afterward. As the conclusions, which I then reached, were called in question, I took occasion before entering the field in 1878 to revisit the locality.

A line of bluffs begins on the west side of the South Platte River at a little way below the mouth of St. Vrain's Creek, and continues until within a mile or two of Thompson Creek. This bluff is more or less distinct on the north side of the St. Vrain for nearly four miles from its mouth. Similar bluffs are conspicuous along the northerly bank of Thompson for several miles, and can be traced thence to near the Cache La Poudre without any difficulty.

A low bluff-like ridge, lying at from one to three miles from the river, begins at Platteville on the east side of the stream, and is easily followed to a considerable distance northeastward from the town of Evans.

In the bluffs lying on the west side of the Platte, the rocks dip gently northward. On the opposite side the dip is insignificant; a very gentle anticlinal was observed at Platteville, and the rocks are almost horizontal or possibly dipping slightly toward the north at four miles southeast from Evans.

On the West side of the South Platte River.—Following the grade of the Colorado Central Railroad on the west side of the river, one finds, somewhat more than four miles above Evans, an outcrop of bright yellow, very friable sandstone, forming a broad band on the bluff. Fragmentary outcroppings of the same rock were observed farther down the river, but here for the first time the exposure is satisfactory.

On the Thompson, the exposure ends with the curving bluff at probably five miles from the river, and the dip along the stream is insignificant.

As already stated, the bluff begins again on the south side of the Thompson probably two miles from that stream, and is continuous thence to within a short distance of the St. Vrain.

Here again is a fine exposure of the sandstone which shows a gentle east-northeast dip. The section up to the St. Vrain is as follows, the thicknesses being estimated:

1.	Yellow sandstone	450 feet.
2.	Blue sandstone	200 "
3.	Concealed	200 "
4.	Yellow sandstone	100 "
5.	Gray to blue sandstone	50 "
	Total	1,000 "

No. 1, the sandstone already referred to as occurring in the bluffs both north and south from the Thompson, is bright yellow and for the most part extremely friable, weathering easily and breaking down into loose sand. But, at irregular intervals, vertically, it shows thin layers of darker sandstone, some of which are quite compact, while others are flaggy, though they all resist the action of the weather. The unequal resistance to the weather is so marked that south from the Thompson the bluffs are known as the Monument Bluffs. The features are exactly the same as those shown in Monument Park, north from Colorado Springs, and the peculiar forms exhibited in photographs, taken by Mr. Jackson in that Park, are accurately reproduced here. So closely do the rocks on the Platte and St. Vrain resemble those in Monument Park, that one might well be tempted to imagine that they are parts of one series, and that the series is continuous along the whole face of the mountain.

This locality was visited by me in 1873,* in company with Mr. J. A. P. Kelley of Evans. and in 1878 with Dr. J. Innes and Mr. S. A. Stevenson of Evans, and Mr. A. J. McClure of Bellefonte, Penn. For the greater portion, the soft, yellow sandstones are devoid of fossils, but here and there *Halymenites major* Lesqx. occurs, and occasionally one stumbles on a little nest of *Ostrea*. The harder layers are quite different, many of the more compact being crowded with the *Halymenites*, while most of the flaggy layers contain Fox Hills fossils, among which are *Ammonites lobatus*, *Nucula cancellata*, *Mactra Warrenana*, and numerous other species. Other layers are crowded with fragments of carbonized wood, and frequently one finds in such layers oblong cavities, six inches long, filled with carbonaceous matter in oolite grains and closely resembling the roe of a large fish. In 1873, Mr. Kelley discovered a thin layer containing impressions of dicotyledonous leaves. But the leaf specimens, with nearly all the other specimens obtained during that visit,

* Notes on the observations made in 1873 were published in the Proc. Lyc. Nat. Hist. of N. Y. for Jan., 1874; in the Proc. Amer. Phil. Soc. for 1875; and in the report to Lt. Wheeler, published in 1876.

were destroyed by an accident to the building where they were stored in Evans. During my last visit the leaf bed could not be found.

These fossils can be procured between the Thompson and St. Vrain from a high knob near the Stone House, but localities are numerous both north and south from the Thompson, specimens having been obtained by me from both sides of that stream, and from the north side by persons connected with the Geological Survey of the Territories.

The blue sandstone appears first above the Stone House, and physically differs little from the overlying yellow sandstone. It contains, however, no inconsiderable proportion of shale, while shaly layers are few in the other rock.

The interval, No. 3, as given in the section is too small, but no direct means of determining the thickness was at my disposal, and the calculation was made roughly by depending on the rate of dip at the southern termination of the bluffs at St. Vrain. The sandstones at the base of the section are exposed on the St. Vrain at nearly three miles from the river. They resemble the higher sandstones in structure, and as far as examined proved to be non-fossiliferous.

The relation of this enormous mass of sandstone to the coal beds mined by the St. Vrain Company could not be made out directly, as there is no way of connecting the exposures; but a barometric line carried over to the mines seems to indicate that the coal at those works lies not far from the horizon of the concealed interval. There is no evidence that any faults exist in this vicinity. Coaly material was obtained in borings, begun on the north side of St. Vrian in the sandstone at the base of the section.

On the East side of the South Platte River.—In 1874, Dr. J. Innes made several borings in search of coal at about five miles southeast from Evans. No. 1 was begun in dull, yellow sandstone, moderately coarse, containing small ferruginous nodules with *Halymenites major* and shells; but only fragments of the latter were seen, sufficient, however, to show that they belong to characteristic species of the Fox Hills group. This boring was carried 268 feet and gave the following section:

1.	Sandstone	52 feet.
2.	Carbonaceous shale	4 "
3.	Yellow sandstone	10 "
4.	Light shale	50 "
5.	White sandstone	40 "
6.	Blue shale	10 "
7.	Blue sandstone	10 "
8.	Alternations of sandstone and shale	92 "
	Total	268 "

Certainly very different from anything exposed on the western side of the river. The rocks here are almost horizontal, but there seems to be a very slight dip toward the north. Accompanied by Dr. Innes, and Messrs. Miller and Stevenson of Evans, I followed up the gulch from this boring to No. 2, which is but a short distance from the last and only a few feet higher. Between the two is a blossom of *coal* or carbonaceous shale. Almost immediately north from the gulch and at barely 100 feet above No. 1, a third boring was put down, in which the following section was obtained:

1.	Dirt	10	feet.	
2.	Sandstone	10	"	
3.	Fire clay	2	"	
4.	Sandstone	14	"	
5.	*Black shale*	16	"	
6.	Sandstone	21	"	
7.	Fire clay	1	foot.	
8.	*Coal* with a little shale	2	feet	10 inches.
9.	Interval	28	"	3 "
10.	*Coal*	0	"	2 "
	Total	105	"	3 "

The black shale, No. 5, is very carbonaceous throughout, and No. 10 is in close proximity to the dark shale or *coal* seen between borings No. 1 and No. 2, which rests almost directly on the sandstone at the top of the section in No. 1.

At fourteen feet above the curb of this boring, a shaft was begun in order to reach the *coal bed*, No. 8 of the section; but after it had been sunk to a depth of twenty-eight feet, Dr. Innes made a boring to determine the character of the coal once more. In this, the upper portion of the shale, No. 5 was found to be a *coal bed* two feet seven inches thick; the *coal bed*, No. 8, was unchanged in thickness, while the little bed at the bottom of the third boring had swelled to six inches. But of the three beds only the middle one showed good coal, that from the others being very soft and of not merchantable quality.

The shaft shows 10 feet of debris resting on eighteen feet of sandstone. The latter contains several fine-grained, somewhat ferruginous layers, which are crowded with remains of Fox Hills species, of which many weathered specimens still lie round the dump. The best specimens obtained were carried away as the work advanced, but a box of them was selected by Dr. Innes, and sent to me in 1874 by Mr. J. A. P. Kelley of Evans. This contained the following species: *Ammonites lobatus, Cardium speciosum, Nucula cancellata, Mactra alta, Mactra Warrenana, Lunatia Moreauensis* and undetermined species of *Anchura*. Fragments of these were seen on the dump, and some good specimens of the univalves were obtained.

At a little distance from this shaft another boring was made, which shows eleven beds of coal in the same interval, which vary in thickness from two to thirty-one inches.

One cannot join the exposures on the east, with those on the west side of the river, as the terraced plains of the Platte are very broad from Platteville to far below Evans. At the same time, the fucoids and the mollusks are fully characteristic of the Fox Hills group, and show that the rocks on both sides of the river are of the same age. Those on the east side have been regarded as without doubt belonging to the Laramie, not to the Fox Hills Group.

The bluffs on the west side between the Thompson and the St. Vrain have been colored as *Laramie* on Dr. Hayden's map. These bluffs show Fox Hills fossils to the top; they contain no coal; no leaf-impressions were found by Dr. Hayden's corps. It is difficult to understand, therefore, why the richly fossiliferous sandstones of the bluffs should be colored as Laramie, while the underlying sandstones, without characteristic features, should be colored as Fox Hills. The bluffs along the Platte, both north and south from the Thompson and those on both sides of the Thompson, are *Fox Hills* and *Fox Hills* only. No higher rocks are exposed between Thompson and St. Vrain within five miles west from the Platte.

ART. XLV.—*Note on the Spectrum of Brorsen's Comet;* by Professor C. A. YOUNG, of Princeton, N. J.

AFTER several unsuccessful attempts, I have at last, on April 1st and 2d, obtained fairly satisfactory observations of the spectrum of this comet. It consists of three bands, like the spectra of all the other comets hitherto observed, the bands being well defined at the lower (least refrangible) edge and fading out towards the upper. The spectrum is so faint that observation is very difficult, and I was able to determine the position of only one of the bands—that in the green, which is much brighter than the other two.

The instrument employed was the 9½ inch refractor of our new observatory, armed with a one-prism spectroscope of sufficient dispersive power to separate the D lines clearly; the eyepiece has a micrometer which carries a bar thick enough to be seen on the back-ground of even a very feeble spectrum. The observation was made by placing the bar so that the bright edge of the band should be just visible as a thin line, the rest of the band being occulted. The instrument has also a scale like that of the ordinary chemical spectroscope, and the position of the micrometer-bar is determined both by the reading

of the micrometer-screw and by the reading of the scale, illuminated for a moment after the bar has been set.

On April 1st I got three scale readings—respectively 99·9, 100·0 and 100·4, the value of one scale division in this part of the spectrum being very nearly 25 units of Ångström's scale, or about double the distance between the extreme lines of the *b* group, the readings decreasing with the wave length.

Just before dark b_1 in the spectrum of daylight coincided with 100 on the scale; also, immediately after the third pointing and without disturbing the telescope, spectroscope, or micrometer, the flame of a Bunsen burner was presented to the slit, and the lower edge of the green band in the well-known spectrum of this flame was found to show itself at the edge of the occulting bar precisely where the comet spectrum had been. We may therefore fairly conclude that the lower edge of the central band in the comet spectrum had a wave length of very nearly 517 millionths of a millimeter. The observation of April 3d confirms this, though but a single reading could be obtained. The only special interest in this observation lies in the fact that in 1868 Mr. Huggins obtained a somewhat different result for this same comet.

In an elaborate paper published some years ago by Vogel in Poggendorff's Annalen upon the spectra of comets, he comes to the conclusion that there are several different kinds of cometary spectra, the differences lying merely in the wave-length of the bands. But he seems to have reached this conclusion by assigning rather too high a degree of accuracy to the observations. With the exception of Brorsen's comet, it would seem that the discrepancies between the different results are entirely within the range of probable error, and that there is no valid reason for supposing more than a single cometary spectrum, slightly modified in different comets by differences of pressure and temperature.

It would now appear from my observations that Brorsen's comet also must fall into line with the rest.

I am entirely at a loss how to explain Mr. Huggins's result. It can hardly be that the comet has really changed its spectrum in the meanwhile, and a careful reading of his account (Proc. of the Royal Society, vol. xvi, p. 388) gives no light as to how an error could have crept into his work; on the other hand, every precaution would seem to have been taken.

However this may be, I am quite positive as to the accuracy of my present result—that the middle band of the spectrum of this comet now coincides sensibly (to a one-prism spectroscope) with the green band in the hydrocarbon spectrum.

The comet is moving very nearly in the path assigned by the ephemeris of Schulze. It is easily visible in the 3-inch finder of the equatorial, and in the telescope itself appears as

a round nebulosity, between 30″ and 40″ in diameter, without definite nucleus, though much brighter in the center. Before the new moon a faint tail was visible, about one-half degree in length. It appeared like a thin streamer, much narrower than the head of the comet, perfectly straight, and directed from the sun.

Princeton, N. J., April 5, 1879.

ART. XLVI.—*On the Hudson River Age of the Taconic Schists, and on the Dependent Relations of the Dutchess County and Western Connecticut Limestone belts;* by JAMES D. DANA.

THE paper by the writer on the Relations of the Geology of Vermont to that of Berkshire, in volume xiv of this Journal (1877), closed (on p. 264) with the following paragraph:

"The magnitude of the results are strong evidence that the so-called limestone-area is really but a small part of a larger region of cotemporaneous disturbance and uplift. The true breadth of the area, as well as length—whether it reached to the Connecticut Valley on the east and to the Hudson River Valley on the west, and so had the breadth of the Appalachian disturbance of a later epoch, or whether it had narrower limits—may be ascertained by studying the stratification. Some of the results of such a study as regards Connecticut and a portion of New York I propose to give in another paper."

Since the above was written I have spent much time in endeavoring to complete my observations in Connecticut and the neighboring counties of New York. I have sought to determine the strike and dip and stratigraphical relations of the rocks of Western Connecticut—points on which Percival's Report contains little, since he aimed chiefly to describe the *kinds of rocks and their geographical distribution*, and did not note where, in any case, lines of stratification and of lithological distribution were, as is often true, not coördinated.* I have

* Dr. Percival was a very exact man in all his work. He made great numbers of observations on the dip of the crystalline schists of the State, but, unfortunately, did not publish them. They had a secondary importance with him because he believed that the different kinds of crystalline rocks were formed from an original crystallizing magma by successive segregations, and did not credit the ordinary views as to stratification and metamorphism. Lines of bedding very often strike across the boundaries of his lithological areas, showing that the latter as laid down on his map, while of interest, are no guide to the stratification, except in the case of the limestone areas and those of a few other formations of persistent lithological characters. It is due to Percival to say that his theory did not lead him to the slightest perversion of the stratigraphic or other facts before him, but only to a misappreciation of some of their bearings; and had the State of Connecticut been more generous to him in its allowance of time for the completion of the survey, and of money for the publication of his notes, there would have been little left for later geologists to do.

made observations toward the same end, and also widely, over Dutchess and Westchester Counties, New York. The work is still far from finished. But the discoveries by Mr. Dale at Poughkeepsie throw so much light on the general question at issue—the age of the Taconic schists, when they are connected with the facts already learned, that I here anticipate my fuller memoir by a brief statement of the facts and their bearing.

1. On the Hudson River Age of the Taconic Schists.

(1.) The discovery, by Mr. A. Wing, of Trenton fossils, *Trinucleus concentricus* and other species, in beds of the crystalline limestone formation of Vermont that directly adjoin and underlie conformably the slates of the north-and-south Taconic belt, has established the fact that these Vermont slates are of the age of the Upper Trenton or the Hudson River group; and the fact that this Taconic belt continues southward, in an uninterrupted line, into and through Western Massachusetts, constituting the Taconic Mountains (lying on the boundary between that State and New York), and the additional fact that the same great limestone formation follows the belt through its course and underlies, in a synclinal, its slates or schists—as the writer has shown, the limestone of the east side dipping under the mountains and becoming the limestone of Copake and Hillsdale on the west—affords scarcely less positive proof that these Berkshire Taconic slates also, the original typical Taconic slates of Emmons long supposed to be Cambrian or pre-Silurian, are of Hudson River age.

This conclusion loses nothing of its certainty in consequence of the fact of a change in the schists of the belt from argillaceous schists at the north (one source of the roofing-slate industry of Vermont), to hydromica, chloritic and garnetiferous mica schists, and staurolitic schists, toward the south extremity of the mountains; for the introduction of hydromica schists (formerly called *magnesian* and *talcose schists*) takes place in Vermont not far from the localities that afforded the fossils; and these hydromica schists continue the whole length of the belt, though more chloritic, more coarsely micaceous, and often garnetiferous, to the south. As to the synclinal of the Mt. Washington portion of the Taconic range in southwestern Massachusetts, Professor W. W. Mather, in a section on Plate 16 of his New York Geological Report (1843), across the mountains fifteen miles farther south, represents the limestone of Salisbury as dipping *westward* beneath the slates while those of the west dip eastward, as they do elsewhere on that side of the mountains. Further; my own recent observations in Northern Salisbury, within three miles of the Massachusetts line, confirm those which I made just north in Western Sheffield;

that the limestone along the eastern foot of the mountains (near or west of the nearest road to them) dips *westward*—the dip being found to be 45° to 60° to the west, with the strike between N. 3° E. and N. 3° W. (true).

(2.) The recent discovery, by T. Nelson Dale, Jr., of fossils of the Hudson River group in the slates or argillaceous schists of Poughkeepsie, on the Hudson River, (sustaining the early views of the New York geologists, Professor W. W. Mather and Professor James Hall,) affords another line of approach to the Taconic Mountains of Massachusetts, and presents further evidence of their Hudson River age. In the first place, the limestone belt which lies, as above remarked, at the western foot of these mountains along through Hillsdale and Copake, and which is the western side of the mountain synclinal, branches off from Copake south-southwest through middle and western Ancram, and extends along the whole course of the valley of Wappinger Creek to the Hudson River, which it reaches only four miles below Poughkeepsie, with a single interruption of less than three miles; and it is everywhere conformable to the argillaceous schists which border it on the east, including those of Poughkeepsie; and also with those on the west, except along a region of faulting near Bangall and Stissing Mountain (a range bordering the limestone area on the west between Stissingville and Pine Plains.) This continuation of the slates and limestone northeastward, from the Poughkeepsie region to the Copake, renders it highly probable that the same limestone formation which adjoins, and is conformable to, the Hudson River slates or schists of Poughkeepsie, adjoins, is conformable to, and underlies the schists of the Taconic Mountains.

The limestone of Wappinger Valley is the Barnegat limestone of Mather—so named from a locality on the Hudson, south of Poughkeepsie, where it is burnt for lime; and this geologist gives it the course here described, mentioning that it outcrops on the Hudson at the mouth of Wappinger Creek between Barnegat and New Hamburgh, and follows the river northeastward to Copake (not noting the break in it);* and he also states that it appears on the *west* side of the Hudson and stretches on to the south-southwest, passing within one mile of Newburgh, into the town of New Windsor, in which it ends, not far from the Archæan of the New Jersey Highlands, in a small body of water called Little Pond. The writer has examined the limestone at various points along the valley; and he has found the conformability to the slates, stated by Mather, to be very generally true. The limestone area is

* Geol. Rep. 4to, 1843, pages 413 and 437. In the paragraph on p. 437 here referred to, there is some confusion as to the courses of the other Dutchess County limestone areas.

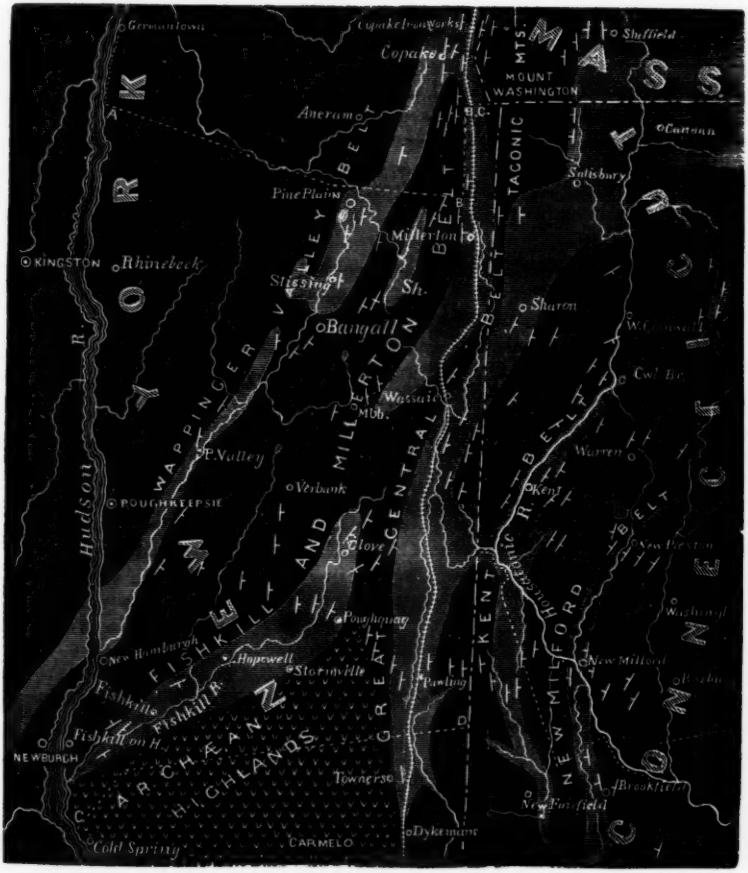
similar to the limestone region east of the Taconic Mountains in having large limonite beds, not only in Copake and farther north, but also in Central Ancram and beyond to the south; among them the Reynold's ore-pit, three to four miles southwest of the Weed ore-pit of Southern Copake, and the Morgan, a mile and a half farther south. Thus the observations accord well with the view that the limestone belt which borders conformably the Hudson River argillaceous schist of Poughkeepsie is the same that borders the Taconic schists in Copake and Hillsdale. If so, since the Copake and Hillsdale, or Western, belt of limestone dips under the Taconic Mountains and comes up, on the east, as the "Great Central belt" of the Green Mountain region, the Barnegat or Wappinger Valley limestone is only a southwestern extension of the great limestone formation that outcrops around Dorset, Rutland and Middlebury, Vermont. The occurrence of limonite beds along the junction between the schists and limestone, as a result of their alteration, in both the eastern and western belts, is an additional mark of general identity.

[On the accompanying map, representing a portion of Eastern New York, with also part of Western Connecticut and the southwest corner of Massachusetts, the general position of two Dutchess County limestone belts is shown, from their outcrops along the Hudson River to their junction with one another in the Copake limestone belt, west of the area of the Taconic Mountains. The map also gives the position of the southern part of the "Great Central" limestone belt of the Green Mountain region, as laid down by Percival on his geological map of Connecticut, from Sheffield in Massachusetts, and Canaan in Connecticut (where it has the width which characterizes it farther north in Berkshire and Vermont), through Salisbury and Sharon, and thence through Eastern New York, here gradually narrowing, to its end among contorted beds of micaceous gneiss eight miles south of Pawling, and just east and north of the Archæan Highlands. These areas, where broadest, include some intercalated beds of schist and isolated schist ridges. The map also gives the position of two eastern limestone belts in Connecticut, that of Kent and Cornwall, and that of Brookfield and New Milford. The T-like symbols over the map, indicate the strike and dip from my observations.]

(3.) Besides this stratigraphical evidence we now have *more positive evidence from the occurrence of Trenton fossils in the limestone of some parts of Wappinger Valley.*

Professor Mather makes the statement in his quarto New York Report (repeating it from his Annual Report of 1838), that in a bed of slaty limestone existing in the slates one-and-a-fourth to one-and-a-half miles north of Barnegat, "a few fossils were

Map of Dutchess and the adjoining Counties of Eastern New York, with a portion of Western Connecticut and Southwestern Massachusetts.



Dutchess County is included between the boundary lines AB B.C. on the north, and CD on the south. On the north is Columbia County, and on the south, Putnam. The Archæan Highlands of Putnam County are a continuation of those of Orange County, New York, and Sussex County, New Jersey. The light areas represent areas or belts of limestone. The notched line just west of the Connecticut boundary is the course of the Harlem Railroad. *B. C.*, Boston Corners; *Cwl. Br.*, Cornwall Bridge; *Mbb.*, Mabbittsville; *P. Valley*, Pleasant Valley; *Sh.*, Shekomeko Station, on the Dutchess and Connecticut railroad—the two streams in the adjoining limestone area being tributaries to Shekomeko Brook.

Scale, 1-10th of an inch to a mile.

found that have been recognized as belonging to the Trenton limestone."* The names of the species are not given. The Barnegat limestone is not far distant to the south and is the next adjoining stratum. The Poughkeepsie slates dip *beneath* the limestone, the dip being southeastward. But if the rocks are in folds and the limestone makes an *anticlinal*, it is an inferior bed notwithstanding the position.† In the Barnegat or Wappinger Valley limestone, which is a dark gray, semi-crystalline rock, Professor Mather found no distinct fossils. He states that his assistant, Professor C. Briggs, "in making his section from Poughkeepsie to Canaan in Connecticut, discovered faint traces of shells at a quarry a little south of Pleasant Valley on the bank of Wappinger's Creek; but they were too imperfect for determination. They were situated between the slaty layers, which have a dip to the south-southeast of 35° to 40°." Mather quotes also Professor Briggs as reporting that Mr. William Thorn of this place (Pleasant Valley) had informed him that "he had often seen shells in the lime rock, although they are rare."‡

Had Professor Mather himself visited that quarry half a mile southwest of Pleasant Valley (about seven miles northeast of Poughkeepsie), he would not have left the fossiliferous character of the limestone in doubt, and inserted discrediting remarks in his Report. Besides, Logan's unfortunate idea of the Quebec group extending over the region, and some other wrong geological inferences, would never have had birth. At a visit to the locality this spring, in order to ascertain the facts in the case (in which I was accompanied by Professor Wm. B. Dwight of Vassar College, Poughkeepsie) I found fossils abundant and distinct. Among them we observed at the time of our visit, remains of two or three species of *Crinoids*, *Cyathophylloid corals*, *Leptæna sericea*, *Orthis tricenaria*, *O. testudinaria*, *Orthoceras junceum*,§ forms suggesting *Strophomena alternata* and fragments of *Trilobites*. What appeared to be the rounded pebbles of a conglomerate layer, proved to be worn specimens of a *Chætetes* ——? with columns not over 1-250th of an inch in diameter. The snow was deep over the country (so deep that our geological excursion was made "on runners," since either "on foot" or "on wheels" would have been attended with some difficulty), and hence a full examination of the locality could not then be made. It cannot be, for the

* Page 401.

† Professor Mather calls the Barnegat limestone *Calciferous*, apparently because he had proved a limestone bed above it—that above referred to—to contain Trenton fossils; he could have had no other reason for it, for he says that he had no fossils from it.

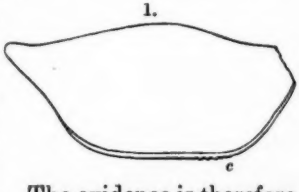
‡ Page 410.

§ The form, size, and distance between the septa, are the same as in this species.

same reason, at the present time (March 21), and I have left the region to be reported on further by Professor Dwight.

Another locality of fossils in the Wappinger Valley limestone at Rochdale, four miles east of Poughkeepsie, had been visited by Professor Dwight the week before—he having been informed with regard to fossils there the day after he received my invitation to join me in the excursion—and it is not less prolific. Great surfaces are covered with the Crinoidal remains, and all the species observed at Pleasant Valley are found there; and, besides, a portion of an *Endoceras*, ten inches long and two inches wide at its larger end, and remains of large specimens of *Receptaculites*. I refer to the article following this for Professor Dwight's preliminary account of the fossils.

Previously, early in December (the day before the first snow-storm of the late snowy winter), I made a search for fossils at the northern end of the Wappinger Valley limestone, in eastern Ancram, just west of the extremity of Winchell's Mountain and not three miles distant from the Taconic Mountains, and found what I then and now believe to be the common Trenton species, *Orthis occidentalis*;* and with it there is another kind, of uncertain character, which may possibly be the Trenton *Strophomena alternata*. The specimen of the *Orthis* presents to view a section of the shell, having the size, form and thickness indicated in the accompanying figure. The thin shell is converted into white calcite (through the metamorphism) excepting in some parts an extremely thin exterior layer; and over a portion of the exterior (at *c*) there are sections of a few of the costæ. The hinge side of the shell is wanting in the specimen. A horizontal section made through the more convex (or ventral) valve was found to have the form which it should have if of the species here supposed; and so for the other valve. The evidence is therefore quite strong in favor of its being this common Trenton Brachiopod.



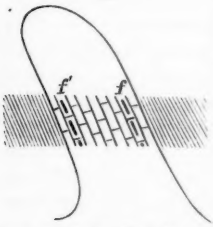
The forms referred doubtingly to *Strophomena alternata* have the arcuated outline, shape and thickness, that would belong to sections of this arcuate shell. They are of white calcite and correspond to individuals one to two inches broad and diminishing mostly from a fourth to a sixteenth of an inch in thickness. Besides the sections, there are also broad concave surfaces like the inner surface of valves. No appearance of striation can be detected in connection with any of the forms.

* The specimens were from a large freshly broken mass of limestone by the road side that was evidently derived from an outcrop near by.

I have been again over the Ancram region, but without finding other specimens—the limestone being much more crystalline than it is toward Poughkeepsie.

The fossils of Pleasant Valley and Rochdale, prove that the limestone of Wappinger Creek Valley contains a stratum of the age of the Trenton; and that of Ancram has the same bearing. The width of the part of the belt at the two former places is two-thirds to three-fourths of a mile; and since the bed containing the fossils is, at each of these localities, within 200 to 230 yards of the *eastern margin* of the limestone belt, it is probably one and the same bed. The lithological character of the rock sustains this. The *western margin* lies conformably against the Poughkeepsie "Hudson River" slate; and hence the western portion also must be Trenton. It follows then: *first*, that the belt is an anticlinal of limestone (as represented in the figure, *f*, toward the east side, being the observed fossiliferous bed); and, *secondly*, that the slate on the *east* of it is of Hudson River age, as well as that *west*. Further: these facts, and the concurring evidence from Ancram, where the limestone is essentially the Copake limestone, leave little doubt that Trenton beds continue northward to the very foot of the Taconic Mountains; and that the schists of the Taconic Mountains, like those of either side of the Wappinger Valley, including Winchell's Mountain, *are Hudson River in age.*

2.



The Wappinger Valley belt may have at centre a Chazy or other subjacent limestone stratum; and if so, the fact would only make more complete the identity of the Poughkeepsie and Vermont formations.

In the vicinity of Stissing Mountain there are quartzyte outcrops; and, if the rock is of the age of the Potsdam sandstone, the portion of the limestone next adjoining may be Calciferous. The mountain consists of fine-grained, gray gneiss, along with slate on the west, and at the southern end the gneiss contains minute zircons; I reserve the discussion of the age of the gneiss for another paper—the first draught of which was made nearly eight years since.

(4.) But this Wappinger Valley limestone is not the only southward extension of the Copake limestone. Another (see Map) extends from it southward by the western foot of the Taconic Mountains through Boston Corners and Millerton; and in the vicinity of the latter place it has its limonite beds. Thence it takes a south-by-west course through Western Amenia, and

Eastern Washington. It stops in the latter town just east of Mabbitsville. But six miles south, in the next town, Unionvale, it appears again in the valley of the Clove, and follows Fishkill Creek to its junction with the Hudson. At Poughquag, it has the extraordinary breadth of three miles, and it continues to have great width past the village of Old Fishkill; but it then narrows, becomes confined to the south side of the Fishkill Creek in Glenham, and is very narrow toward the mouth of the creek.* It evidently loses in breadth in this part because of its nearing the Archæan region of the Highlands, which is not half a mile distant; and its more western course from Poughquag to the Hudson has the same origin. The Hudson River slates border it conformably on the north. Limonite beds occur along this belt in Unionvale, where is the Clove ore bed, two on Sylvan Lake, and one in East Fishkill.

Through this Millerton-and-Fishkill belt of limestone there is hence a second connection between the Hudson River slates of the borders of the Hudson River region and the schists of the Taconic Mountains.

The limestone is throughout as decidedly crystalline as in the northern half of the Wappinger Valley belt (though never coarsely so); and hence fossils would be uncommon if occurring in it at all. In many places forms suggesting a fossil origin are to be met with.

Wherever the limestone contains seams of quartz such indications rarely occur, the most suggestive appearances being small and thin isolated bits of quartz, arcuate in section. Since the silicification, or the making of the siliceous seams, was carried forward by *hot* siliceous waters (not *cold*, as in the case of silicified shells in an unaltered limestone) during a time of metamorphism in which the limestone was crystallized and quartz veins were made in the slates or schists, fossils, if any were present, would naturally have been dissolved away. Almost the only chance for recognizable forms is in places where the limestone is without quartz, and the seams and spots it contains are of white calcite. One of this kind, which I observed in the limestone seven miles north of Millerton, near the base of the Taconic Mountains, seemed to be part of a valve of a ribbed Brachiopod, and others of like suggestiveness were met with in some of the limestone cuts between Hopewell and Fishkill. Such appearances favor the expectation that distinct fossils may yet be found in this belt. Three

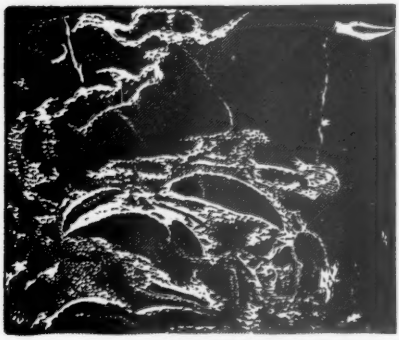
* I found the limestone outcropping at the village of Lithgow, and east of Mabbitsville (*Mbb.* on map), as stated by Mather. South of this, the country is high, the elevated region to the eastward (called farther south Chestnut Ridge) spreading over it, and having its rocks small in dip, with undulations, and with the limestone evidently concealed beneath. The limestone reappears where the valley opens again, along Clove Brook, and is thence continuous to the Hudson.

miles west of Hopewell I obtained specimens looking closely like the Wappinger Valley *Chætetes*, but with its structure lost.

Between the Wappinger-Valley and Fishkill-and-Millerton belts, there are other outcrops of limestone.

One area, nearly six miles long, lies between the northern ends of these belts, in the Shekomeko Valley. (See the map.) Winchell's Mountain bounds it on the east, and Husted station is toward its northern extremity. The limestone is similar to that of the Fishkill-and-Millerton belt, but has in many parts a delicate bedding that shows the action of slowly moving water during its accumulation. The accompanying figure (from a photograph) represents, natural size, figures on a specimen of blue limestone, from a ledge near Shekomeko Station (*Sh.*), which are of white calcite and similar to those alluded to above as suggestive of Brachiopods. Another specimen contains a group of *black* curving surfaces, which are unquestionably of organic origin, and look like impressions of a few successive broken segments of a *Trilobite* 1¼ in. broad.

3.



Another area exists just below the Verbank railroad station, where two small hills of a badly rifted, quartz-seamed, gnarled limestone occur, which is various in strike, but mostly nearly north and south, and is without continuation at surface either north or south. A third occurs at Arthursburg, hardly eight miles south of Verbank. I learn from Professor Dwight, that a ledge, 1,800 feet wide occurs two miles southeast of Pleasant Valley. Mather mentions one between Redhook and Milan.

Over the country between the two Dutchess County limestone belts, the dip, excluding some local exceptions, is eastward (mostly between east-by-south and east-southeast) and the beds, as has been stated, are all conformable. It is true that the *cleavage* of slates is not always conformable to the stratification; but since over this region the lamination in them corresponds in all cases with the bedding of the many intervening limestone strata, the uncertainties which are thus introduced do not affect the above general statement as to conformability and eastward dip. In a supplement to this paper, the actual dips and courses observed, will be given.

Rocks.—The schists and limestone east of the Taconic Mountains are more crystalline than those *west*, and the crystalline

character diminishes from these mountains *westward* toward the Hudson, just as it diminishes along their line northward toward Central Vermont. The rocks are mica schist and hydromica schist, and to the south micaceous gneiss, over the eastern part of Dutchess County; but, approaching Poughkeepsie, the schist in part fails even of the glossy luster, and becomes dull argillaceous and partly carbonaceous schist. North of Dutchess County, in Columbia County, argillaceous schist is the prevailing rock, and it is often carbonaceous in Ancram and part of Copake. The micaceous gneiss of the Taconic schist belt is well seen two miles west of Pawling; and here, against its eastern side, between it and the limestone, there lies a large limonite ore-bed. And this gneiss-like character continues to its extremity, south of Towner's, where, in a dry portion of a large marsh, north of Croton Lake, the limestone is exposed to view, alternating with coarse gneiss. In the slate ridge next west, the northern extremity of which is called Winchell's Mountain (west of Boston Corners and Millerton), the rock is argillyte, and hydromica schist, partly chloritic; but to the south, it becomes gradually coarser, being a mica schist on its eastern or more crystalline side, at Wassaic; and ten miles farther south, a decided mica schist on its western side, and still coarser on the east; and even gneissoid south of this.* Mather recognized the same changes, in this range of slate, stating it thus (Rep. N. Y. Geol., p. 433): "in its northern part, of slate and talcose and chloritic slates; the middle part, of mica slate; and the southern portion, of gneiss." The extremity of the "Great Central" limestone belt is in the area of Croton lake.†

The facts in Dutchess County thus show that argillaceous schist, hydromica schist, mica schist of garnetiferous, chloritic, staurolitic and other varieties, and micaceous gneiss, which are the occurring rocks of the so-called "Taconic system" or "Taconian," are here of one and the same age, and they leave little reason to doubt that they are, together, *of the age of the Hudson River Group.*

Quartzyte occurs adjoining the Archæan, southwest of Matteawan, three miles from the Hudson River—a locality pointed out to me by Mr. Charles M. Wolcott of Fishkill. The quartzyte

* According to a section by Prof. N. H. Winchell (received by the author from him in 1872) from the top of Winchell's Mountain eastward to Lakeville, seven miles, along a line ¾ m. north of Millerton, the rock of Winchell's Mountain west of the summit is argillyte, and east of it mica schist; next east is the Millerton limestone nearly two miles wide; next, mica schist, of the same width, having, on the west a thin stratum of "compact, fibrous hornblende schist, somewhat micaceous" (as seen in a section on the Connecticut Western R. R.); and then, the limestone of Lakeville. The dip is stated to be north of east, except at Lakeville where there is a low anticlinal.

† It is rather probable that an outcrop exists two miles farther south, in the site of another pond south of Dykeman's, though none is in view. There is here a final termination of the valley by high Archæan hills.

was jointed and obscure in its bedding; but since a limonite deposit (usually situated in these regions, between conformable strata of schist or quartzyte and limestone) adjoins it, and the proprietor, Mr. Wolcott, found this one resting on beds approaching the quartzyte in character, it is very probable that the stratum is conformable with the limestone, whose outcrops are not far distant, and that it is of the age of the Potsdam sandstone. The adjoining portion of the limestone may hence prove to be Calciferous or Chazy. Quartzyte rests on the Archæan also at Poughquag, but in nearly horizontal beds (see this Journal, III, iii, 250, 1872) indicating a fault between it and the adjoining limestone. Mather mentions its occurrence also at Shenandoah.

At Glenham near Fishkill, a flesh-red, coarse granite-like stratum (or "bastard granite," as it has been called) lies between the limestone and the slate, conformable to both; and it is evidently one of the stratified deposits, as is shown by its conformable position, and its taking the color of the slate near the junction. The adjacent Archæan Highlands were the source of the coarse granitic sand of which it was made.

2. Dependent Relations of the two Dutchess County limestone belts and two Eastern belts in Connecticut.

The preceding map also represents, from Percival, two eastern belts of limestone in Connecticut, the *Kent* belt and the *New Milford* belt; and I may add that I have been over these regions pretty thoroughly, and can attest to Percival's correctness.

Viewing these belts and the three to the west together, and remembering that the Great Central belt is identified with the Green Mountains through Massachusetts and far into Vermont, it seems to be a safe conclusion that all are parts of one system; and that they owe their existence to a series of extensive cotemporaneously-made folds of the wide-spread Lower Silurian formation of the region. The New Milford and Kent belts are the *opposite sides of a synclinal;* for the schistose rocks between have, as I have found, a westward dip along the eastern portion, and an eastward dip along the western portion, as indicated by the symbols for the dip and strike on the map. The Great Central belt and the Kent belt *pass one into the other* in the vicinity of South Dover (see map), and also to the north in the eastern part of Canaan, and thus they are one.

Over the large gneiss area next west of Kent, the schistose rocks are, for the most part, conformable to the adjoining limestone belts—the strike about N. 20° E. along the southern half and on the eastern side of the northern half, and with N. 50° E. as the average near the Housatonic River, as if from a

wrench in the mass. On the southern portion of the *east* side both north and south of Kent, and also along a large part of the *west* side, the rock adjoining the limestone is *quartzyte;* and next follows gneiss; *the quartzyte in several places is gneissoid, and graduates into the hard gneiss.* South of Sharon, the rock next to the quartzyte is *granulyte*, and there is a partial transition from one to the other. The quartzyte of the two sides of the area is, with little doubt, the same stratum, and probably the Potsdam sandstone; and in that case the conformable gneiss will correspond to inferior beds of the Primordial, and the adjoining portion of the limestone belts may be Calciferous; further, the strata make an anticlinal over the intervening area of gneiss. This area includes some unconformable ledges, both in the northern and southern half, in which occur chondroditic limestone, syenyte, beds of titaniferous magnetite, and hard gneisses, which may be Archæan; and if so, they are outliers of the large Archæan area of the Highlands which exists to the southwest.

3. Influence of the Limestone belts on the Features of the Surface.

Limestone being a brittle rock, the region of flexures, whatever the thickness of the overlying mass, would have been profoundly fractured, especially in anticlinals; and being also a soft rock, it would have been easily carried away by denuding agencies. The limestone belts are the chief courses, as Percival pointed out, of all the greater valleys and streams of the limestone region; and in these valleys, as I have found, the underdipping side of the limestone is generally the bold, precipitous side, owing to the undermining which it has occasioned. This is so generally true that vertical fronts in these metamorphic regions (and I may add in Westchester County as well as farther north and northeast) are pretty sure evidence of outcropping limestone below.

4. Conclusions.

1. The Taconic schists are, according to the evidence, of the age of the Hudson River group.

2. The conformability in the rocks between the eastern of the Connecticut belts and the Hudson, being established by observation, the five limestone belts are plainly, as above suggested, but five outcropping bands of the Lower Silurian limestone formations, brought to the surface by a series of flexures.

3. The disturbance which upturned and crystallized the limestones and other conformable formations in the Green Mountain area, through Vermont and Massachusetts, extended south over

certainly a large part of Western Connecticut, and over Eastern New York at least to the Hudson.

That hard gneisses and mica schists are among the included formations does not, in any way, affect the evidence or the conclusions here deduced.

These conclusions coincide partly with those reached by Professor Mather, as stated on pages 438, 464, and 628 of his Report, namely: (1) That the limestone of Eastern New York and the Green Mountain region, including that of Westchester County down to New York Island, is of the Trenton or Calciferous (Canadian) periods; (2) that the slates, gneiss, mica schist and other rocks, directly associated with the limestone in Massachusetts and elsewhere, are of the Hudson River age; (3) that the quartzyte is of the age of the Potsdam; (4) that the making of the Green Mountains and the metamorphism of Western New England, took place at the close of the Lower Silurian. Proposition (1) appears to me to be established, if we admit, in addition, that the limestone may in some places be in part Primordial, and leave out of consideration, for the present, that of Westchester County. Proposition (2) is pretty well demonstrated as far as the slates or schists of the Taconic Range are concerned; but,—as I present in the second of my articles on Berkshire geology—we cannot say now of the gneiss and mica schist ridges to the east of the Taconic range more than this, that they are Lower Silurian; and among the gneisses are those also of local Archæan areas. Proposition (3) is almost certainly true for part of the quartzyte, but it is not yet safe to say this of all. Proposition (4) has strong support in all the observations which I have made in the Green Mountain region.

Professor Mather has a separate chapter on "Primary rocks" under which head he includes the rocks of the Highlands, and, with these, the gneisses and mica schists of Westchester County and New York Island. The distribution of the limestone areas of Westchester County with reference to one another and those of Connecticut, and their stratigraphical relations to the gneisses and mica schists associated with them, are a basis of evidence on this question of age, and the facts I have observed and mapped I shall present in a following number of this Journal.

The nature and stratification of the schistose rocks intervening between the Connecticut limestone belts I have studied with some detail, and I propose, after further investigations, and the removal of some doubts as to the limits of the included Archæan, to make these also the subject of another paper.

ART. XLVII.—*On some recent Explorations in the Wappinger Valley Limestone of Dutchess County, New York;* by Professor WM. B. DWIGHT, of Vassar College, Poughkeepsie, N. Y.

MY attention was called to the possible fossiliferous character of the Wappinger Valley limestone by an invitation from Professor Dana to join him in examinations at Pleasant Valley, of a reported locality of fossils doubtingly mentioned by Professor Mather.* In order to further the object in view, I made enquiries with regard to another reputed locality, at Rochdale, and the next day I was gratified to find the limestone there abounding in fossils. Since the excursion to this place and Pleasant Valley with Professor Dana, which took place a few days later, I have continued my search in the Barnegat or Wappinger Creek limestone, he leaving the field to me, and have discovered still other localities; and it is the object of this paper to mention the facts thus far ascertained.

As my acquaintance with this part of the country has been but a brief one, and as my researches have been conducted in the scanty hours that could be snatched from my collegiate work during the last four weeks, the results which I here put on record should be regarded as merely preliminary to the more careful investigations of this interesting formation which I hope to make.

The first locality which I examined was one at Rochdale, above alluded to, where objects of peculiar forms had been reported to have been found, though there is no evidence of any scientific examination. It is situated four miles northeast of Poughkeepsie, on the premises of Mr. Henry Titus.† The limestone here has a dip of 60° southeasterly, with a strike of N. 36° E. (true). The examination, though short, afforded me abundant evidence of fossils, and some determinable species, as follows:—*Leptæna sericea*, an internal cast of the ventral valve, showing the characteristic form of the callosities for visceral attachment, and the striæ in reverse; two specimens of *Orthis tricenaria;* small encrinal columns in countless numbers; a spiral shell, two and a half centimeters in diameter, exhibited only in section, imbedded in the rock.

Besides these, there are many specimens of a species of *Receptaculites.* Groups of cylindrical or club-shaped columns, half an inch or so long, project inward, somewhat radially, from a hollow but rather firm shell of irregular form which varies much

* N. Y. Geol. Report, 1843.

† I take this occasion to acknowledge my indebtedness to Professor T. J. Backus, of Vassar College, for information of this locality, and assistance in pointing out fossils, and to Messrs. Henry and Richard Titus, proprietors of the Rochdale woolen mills, for courteous coöperation in the work.

in size; they consist of the limestone and are evidently the fillings of the tubes of Receptaculites. They are so imbedded in the rock that I have not yet been able to detach any for special study, as I propose soon to do.

My second trip to this locality, a week later, was made in company with Professor Dana. I found, at this time, another distinct specimen of *Leptæna sericea*, one *Escharopora recta*, one *Ptilodictya acuta*, a pygidium of a trilobite, several specimens of *Orthis tricenaria*, an *Orthis pectinella*, one *Endoceras* twenty or twenty-five centimeters long, one small *Orthoceras*, two of *Orthis testudinaria*, and some *Chætetes* of minute columnar structure.

On the same occasion we visited a quarry on Wappinger Creek, about half a mile below Pleasant Valley, where Mather reported faint traces of shells to have been found, "too imperfect for identification." We found abundant evidence of the fossiliferous character of the rock, the fossils being generally similar to those at Rochdale. In a subsequent examination of my specimens here collected, I obtained one well-defined specimen, and several small fragments, of *Strophomena alternata*,—showing its characteristic arrangement of striæ; also, very abundantly, the Chætetes found at Rochdale, from two inches to one-quarter or less in diameter. The large specimens are sometimes semi-globular, and suggest *Chætetes lycoperdon*, but for the microscopic tenuity of the columns; but other specimens are pyriform, and I am not certain as to the normal shape. The diameter of the columns is less than 1-200th of an inch. As it appears to be new, I propose for it the name *Ch. tenuissima*.

My subsequent trips have been taken alone. On the farm of Mr. Brittenberger, two miles southeast of Pleasant Valley, east of Wappinger Creek, I found a second and parallel outcrop of limestone, 1800 feet wide, separated by slate from the main body of the Wappinger Valley belt. The rock is here filled with limestone pebbles of various sizes and lighter in color than the mass. Many of these may have been organic, and very likely corals, but crystallization has so obliterated the structure that if detected at all, it must be by microscopic examination. There was one specimen which is probably an encrinal column about seven centimeters long, and seven millimeters wide.

I have made examinations at Salt Point, on Wappinger Creek, at the junction of Salt Point Creek, ten and a half miles northeast from Poughkeepsie, and also at a number of places between Salt Point and Pleasant Valley. At Salt Point the limestone has a width of 2200 feet, and it is about that width, or somewhat wider, toward Pleasant Valley. It is mostly on the west side of the creek, and for a distance of four miles south of Salt Point, it varies from the greater part of the outcrop by

having a westerly dip of 70° to 85°, the strike averaging about N. 26 E. (true). Thus far I have succeeded in finding here only the spiral shell met with at Rochdale, and three small but very distinct Orthocerata. This spiral shell occurs in particular layers extending through this entire section; some specimens appear to be scattered through the rock, but in these layers they exist in immense numbers. On a single surface of 50 square centimeters, which I broke out of the solid rock, there are more than twenty distinct specimens. This is beyond the average, but the specimens are often so numerous as to crowd upon each other.

The best localities I have discovered are in two quarries of F. B. Wallace, on Wappinger's Creek, respectively one and one-quarter and one and one-half miles below Salt Point; and in two cuts on the Poughkeepsie, Hartford and Boston Railroad track, two miles north of Pleasant Valley. Generally only the simple spiral line is preserved in section. In many cases, however, more or less of the tube of the whorls remains, quite hollow, but its surface too granular to allow the preservation of any marking. The spire in many cases shows a depression of about two millimeters below the surface of the outer whorl. In most cases no septa are visible, but among some fine specimens, from the lower Wallace quarry, several show distinct internal, transverse septa. One, which is unusually good and sharply defined, shows as many as fifteen septa in its four whorls in good state of preservation. I have not yet been able to make out clearly a siphuncle. Most of the specimens exhibit four whorls, and some traces of a fifth; the rate of expansion in the width increases gradually, the spirals being closely coiled. A few of these spiral shells are loosely coiled; and some, whose whorls present an angular edge, are of essentially different character from the others. From present appearances I should judge most of these shells to be those of *Trocholites*, but I hope soon to secure more decisive specimens.

At Manchester, three miles east of Poughkeepsie, no organic remains appeared, except a beautiful fucoid, which had much resemblance to *Buthotrephis gracilis*, and covered a large slab of rock.

In a visit to an outcrop on the Hudson River, one and one-half to two miles south of Milton Ferry, I discovered no fossils except a good specimen of *Leptæna sericea*, in the rock quarried from the limestone near where it borders on the shale that lies on its north side.

The results in fossils, of my examinations, the specimens of which were taken in every instance from the solid rock in place, may be summed up as follows:—

From Rochdale.

* *Orthis tricenaria ;* several.
* *O. pectinella ;* one.
* *Leptæna sericea ;* two.
* *Escharopora recta ;* one.
* *Ptilodictya acuta ;* one.
Caudal shield of small trilobite, probably *Asaphus vetustus;* one.
Endoceras (probably *proteiforme*) ; one.
Orthoceras not well defined ; one.
Spiral univalves ; several.
Chætetes, named above *Ch. tenuissima ;* many.
Encrinal columns ; exceedingly numerous.
Receptaculites; numerous.

From Pleasant Valley.

* *Orthis tricenaria ;* several.
* *O. pectinella ;* one.
* *O. testudinaria ;* two.
* *Leptæna sericea ;* one.
* *Strophomena alternata ;* one or more.
Chætetes tenuissima ; very common.
Encrinal columns ; abundant.
Bellerophon ? ; one.
Undetermined corals ; several.

Between Salt Point and Pleasant Valley.

Trocholites ? ; exceedingly numerous.
Oncoceras constrictum ? ; one specimen, two centimeters in length and same in width.
Orthocerata ; one, three centimeters long, with twelve septa; one, about a centimeter long, with five septa.

Manchester.

Fucoids (*Buthotrephis gracilis ?*) ; one.

Besides other conclusions from these researches, the following may be safely drawn:—

1. The "Barnegat limestone," contrary to views hitherto presented, is a highly fossiliferous formation, though on account of alteration, fossiliferous localities are rare compared with the exposure of rock.

2. The fossils are apparently those of the Trenton limestone, and therefore immediately underlie the adjoining shales which are now referred to the Hudson River group.

3. In the presence of the Chætetes of delicate structure, and of the layers thickly packed with spiral shells, the limestone appears to differ from that of any other known region of this formation.

Vassar College, Poughkeepsie, N. Y., April 7, 1879.

* Clearly defined as to specific character.

ART. XLVIII.—*Observations on the Planet discovered March 21st;* by C. H. F. PETERS. (From a letter to the editors dated Litchfield Observatory of Hamilton College, Clinton, N. Y., April 2d, 1879.)

I TAKE pleasure in communicating the following observations on a planet discovered on March 21st, the only ones the bad weather has permitted me to make.

1879.	H. C. mean t.	α (194)	δ (194)	No. of comp.
March 21	$14^h15^m47^s$	$12^h12^m\ 3{\cdot}91^s$	$+\ 9°26'30''{\cdot}2$	20
" 31	9 23 12	12 4 20·07	+11 1 3·9	12
April 1	9 11 13	12 3 34·63	+11 10 1·6	10

The planet is bright eleventh magnitude. On the same evening I found still another planet, 10th magnitude, and observed it;

March 21.
$11^h\ 32^m\ 21^s$ m. t. $\alpha = 11^h\ 58^m\ 45^s{\cdot}49$; $\delta = +9°\ 18'\ 2''{\cdot}8$ (16 comp.)

As my computations from the elements (the Berlin ephemerides have not yet arrived) did not indicate any of the older planets in that place, I had reason to believe this one too a new one, and accordingly gave public notice of it. Professor Foerster, however, remarks that this is *Leto* (68). And indeed, I find now, that in the elements of *Leto* given in the Berlin Jahrbuch there is an error of print made in 1877, and perpetuated through the later volumes until 1880. The epoch printed there, 1874, should read instead 1864.

ART. XLIX.—*Note on the Stratigraphy of the Huronian Series of Northern Wisconsin; and on the Equivalency of the Huronian of the Marquette and Penokee Districts;* by R. D. IRVING.

IN the number of this Journal for September, 1876, Major T. B. Brooks has given, in a scheme of equivalency for the strata of the different Huronian districts in the neighborhood of Lake Superior, a synopsis of the Huronian section on Bad River, Northern Wisconsin, which is quite erroneous. The error has arisen chiefly from the failure to recognize the existence of a very important break in the strata—which break has indeed given the river an opportunity to cut its way through the Penokee range—and also from the difficulty in marking the line between the two great and totally distinct series, the Huronian, and Keweenawan or Copper-bearing series. Major Brooks's section is professedly a rough one only.

I have myself recently completed a study of my field results over the Huronian belt of this part of Wisconsin, as also of over one hundred thin sections of the rock specimens gathered, and have made a section which I think may be regarded as final. A synopsis of this is given below, as it will appear in vol. iv of the Wisconsin reports. I should say here that in beginning my lithological work on the Huronian of this region, I was aided by a detailed microscopic description of nine selected specimens furnished by Mr. A. A. Julien. In the year that has elapsed since then I have familiarized myself with this (to me) new, and all-important method of investigation, and have examined sections from nearly every ledge of importance within the Huronian area.

Synopsis of the Stratigraphy of the Huronian of the Penokee Region, Wisconsin.

LAURENTIAN.

Chloritic hornblende-gneiss and pink quartzose granite.

HURONIAN.

(Non-conformable with the Laurentian.)

Formation.	Average thickness.
I. Tremolitic (Julien) crystalline *limestone*	90 ft.
II. (A) Arenaceous white *quartzite*, often brecciated 35 ft. (B) Magnetitic quartz-schist 5 ft.	40 ft.
III. *Siliceous slaty schists;* including quartzite, "argillitic" mica schist, and novaculite; all having much quartz, and none ever showing any amorphous material	410 ft.
IV. *Magnetic belt*; including (*a*) banded magnetic quartzite—gray to red quartzite, free from, or lean in iron oxides, banded with seams, from a fraction of an inch to several inches in width, of pure black granular magnetite only rarely mingled with the specular oxide; (*b*) magnetitic quartzite—the magnetite in very varying proportions, pretty well scattered throughout, and mingled with the specular oxide in proportions varying from nothing to a predominating quantity; (*c*) magnetitic quartz slate, the magnetite pervading the whole, and mingled with the specular oxide, as before; (*d*) slate like (*c*) but largely charged with tremolite or actinolite; (*e*) arenaceous to compact and flaky quartzite, free or nearly so from iron oxides; (*f*) thin-laminated, soft black magnetitic slate; (*g*) hematitic quartzite, the iron oxide the red variety; (*h*) garnetiferous actinolite schist, or eclogite; (*i*) diorite, which is restricted to the western end of the Huronian belt. Kinds (*a*) to (*d*) all carry much pyrolusite, or other manganese oxide. These varieties have no persistent stratigraphical arrangement, and are named here in order of relative abundance. Total thickness about	780 ft.

Formation.	Average thickness.
V. *Black feldspathic slate;* consisting of orthoclase grains imbedded in a paste of biotite, pyrite, limonite (Julien) and carbon	180 ft.
VI. Unknown, always drift-covered	880 ft.
VII. Dark gray to black, aphanitic *mica-slate*, having a wholly crystalline base of quartz and orthoclase, with disseminated biotite scales	120 ft.
VIII. Unknown, but probably in large part the same as VII	290 ft.
IX. Chloritic, pyritiferous, massive *diorite* (Julien)	150 ft.
X. Black, aphanitic *mica-slate*, like VII	25 ft.
XI. Covered, but probably black mica-slate	280 ft.
XII. *Black mica-slate;* aphanitic; at times chiastolitic (Julien)	225 ft.
XIII. Chloritic *diorite-schist*	35 ft.
XIV. *Black mica-slate*, like XII, often chiastolitic	375 ft.
XV to XVIII. Alternations of black *mica-slates*, with *quartzites* and quartz-schists	675 ft.
XIX. *Greenstone-schist;* aphanitic; the hornblende and plagioclase much altered	260 ft.
XX. Covered; but probably like XXI	525 ft.
XXI. *Mica schist;* from aphanitic to medium-grained; including bands of light-gray quartz-schist, the mica becoming subordinate; all varieties having a background of quartz; the mica wholly biotite; penetrated by veins and masses of very coarse, pink to brick-red biotite granite; total seen on Bad River	4,960 ft.
Total thickness of the Huronian in the Bad River section	10,300 ft.
Add higher layers seen farther east; same as XXII	2,500 ft.
Total	12,800 ft.

KEWEENAWAN.

(Non-conformable with the Huronian.)

Very coarse to fine-grained gabbro, including granite veins and masses.

The Bad River section does not show the entire thickness of the Huronian, for the reason that the overlying gabbros of the Keweenawan Series cut diagonally across the Huronian. Seven miles west of Bad River the whole thickness of strata between the Laurentian gneiss, and Keweenawan gabbro, does not exceed 2,500 feet, while at the same distance eastward it is over 12,000 feet.

Equivalency of the Huronian systems of the Marquette and Penokee Districts.—There can be little doubt that the Huronian basin of Marquette was once directly continuous with that in

which the Penokee rocks were deposited; there are, indeed, no facts yet on record going to show that the two rock-systems are not at the present time directly connected, though at surface the connection is obscured by the overlying horizontal Potsdam sandstone. Pumpelly and Brooks* have carried the Penokee belt uninterruptedly eastward as far as Lake Gogebic, where a deep depression, made by ancient erosion, occupied now by the horizontal sandstone, terminates the range abruptly. From here to the westernmost known portion of the Marquette Huronian is a distance of less than forty miles.

In the Marquette region Major Brooks has made out with great care and skill a succession of beds which he numbers from V to XIX. That essentially the same succession exists in the Penokee region, there can be little doubt. An attempt to make out a scheme of equivalency for basins always disconnected, based on lithology alone, would, beyond doubt, be but time wasted. In the present case, however, the two districts are really continuous, and many of the layers in the two regions so very constant in their characters, that there can be no valid objection to the attempt. It is undoubtedly true that it is very easy to make many mistakes in such a scheme, owing to the dying out of certain layers, and the variations along the line of strike of some member of the series, which, if not originally present, may have been produced by the partial process of metamorphism to which the whole Huronian system has been subjected. No scheme of equivalency can then be regarded as of any value, that is not based upon those few grand features of the stratigraphy, which are shown to be quite constant. The prominent facts in this connection, that have pressed themselves upon me while studying over my field-results in connection with the reports and typical collection of the Michigan survey, are here given. Major Brooks, whose wide experience in the several Huronian regions of the northwest, and whose skill in Huronian stratigraphy, are well known is, I believe, preparing a complete presentation of the whole subject of the equivalency of the strata of the various districts. The following are offered as suggestions toward the fuller treatment of the subject.

In Wisconsin we find at the base of the series a great bed (III) of light-colored quartzose slates and schists, over 400 feet in thickness, with characters so pronounced that it has been traced uninterruptedly for over fifty miles. The rocks of this layer vary from schistose vitreous quartzites, to argillitic mica-schists, while subordinate to it are the two lower members, the white arenaceous quartzite (II) and tremolitic crystalline limestone (III). Now in the Marquette region the base of the series is a

*Geological Survey of Michigan, vol. i, p. 183 of Report on Iron Rocks, and p. 1, of Report on Copper Rocks.

great bed of quartzite (V), including argillitic schists, and limestones, both quite indistinguishable in hand specimens from the Wisconsin rocks. From the descriptions in the Michigan reports this layer is evidently no less prominent and persistent than No. III of our series. It appears evident that the two are directly equivalent.

Above the siliceous slates in the Penokee system we find a great belt (IV) of magnetitic schists, of the several varieties above indicated, which is unquestionably continuous from Lake Nemakagon in township 44, range 6, west; eastward, nearly to Lake Gogebic, a distance of over eighty miles. In Michigan a succession of layers of strictly similar rocks—both macroscopically and microscopically—overlies the great "Lower Quartzite." In Michigan there are intercalated diorite bands. In Wisconsin these are known only toward the western portion of the belt, where they are, however, very prominent. The peculiar garnetiferous rock of the Penokee section has its exact equivalent in the Michigan magnetic belts, while numerous other peculiar details are the same in the two regions. I should then regard the Penokee magnetic belt as equivalent to Nos. VI to XI of Major Brooks' Marquette series.

Immediately above the magnetic belt (IV) of the Penokee system, or separated from it by a band of black slate (V), which is not known to be sufficiently persistent to deserve consideration in the present connection, is always a covered space without exposure, corresponding to nearly 900 feet in thickness of layers (VI). This would appear to be the equivalent of the belt including the rich ores of Michigan (XIII and XIV), a point of some practical interest.

Above this blank space we find the prevailing rock for a thickness of over 2,000 feet to be a black aphanitic mica slate, which includes, however, bands of quartzite, and thinner ones of diorite, besides which there are blank spaces, the nature of whose underlying rock is a matter of conjecture (VII to XVIII). The black slates and interstratified quartzites are known at points along a belt over twenty miles in length. The equivalents of these members, in the Marquette region, appear to lie from XIV to XVIII of Major Brooks's scheme, where we have quartzite and true clay slate, besides brown to black carbonaceous slates, often distinctly micaceous.

Forming the uppermost members of the Penokee system, we find a great development of mica (biotite) schists, equaling in thickness all of the lower members of the series, and including dark gray, aphanitic kinds, quite coarse, gneiss-like kinds, besides highly quartzose kinds. It is certainly a striking fact, that in the Marquette region the uppermost member (XIX), a mica schist, is the thickest of the whole series, covering often a width, according to the Michigan maps, of over a mile.

The granites which Major Brooks places in his scheme as the youngest of the Penokee Huronian (see this Journal for September, 1876) are merely intrusive patches and veins of small size and area, cutting both the upper mica schists of the Huronian, and the lower gabbros of the Keweenawan system. The gabbros are placed unhesitatingly with the Keweenawan, for the following principal reasons: (1) their general mineral composition allies them closely with the typical diabases of the Keweenaw series while contrasting them with the hornblendic Huronian; (2) when followed along the general trend of the formation, they are found giving place to typical Keweenawan diabase and diabase amygdaloid; (3) similar gabbro occurs interstratified with the undoubted Keweenawan rocks; (4) the gabbro belt cuts diagonally across the Huronian, which it narrows in places to less than one-third the full thickness, thus proving a distinct non-conformity. These gabbros are regarded as of igneous origin, having been one of the first of the great flows of the Keweenaw system, and laid down upon the slightly disturbed Huronian beds.

University of Wisconsin, Dec. 31st, 1878.

ART. L.—*On the Composition of the Cymatolite from Goshen, Mass.;* by A. A. JULIEN.

A MINERAL, pseudomorphous after spodumene, occurs in granite veins of Hampshire County, Mass., which appears to be that first found by Shepard, and by him called cymatolite. The variety at Goshen was analyzed by Burton, and, on the ground of his results, has been assigned to pihlite. A specimen, identical in physical characters with the mineral of Shepard, has yielded me the following composition:

		Oxygen.
Water	2·58	2·29
Nitrogenous organic matter	·43	
Potash	8·38	1·42
Soda	2·57	·66
Lithia	·09	·05
Lime	·48	·14
Magnesia	·75	·30
Manganous oxide	·18	·04
Ferric oxide	1·66	·49
Alumina	24·38	11·38
Silica	58·11	30·99
	99·61	

These new results, corresponding by the old system to the formula

$$(\tfrac{1}{3}(\tfrac{1}{2}\dot{H}+\tfrac{1}{2}\dot{K}\,.\,\dot{N}a)^3+\tfrac{2}{3}\ddot{A}l)\ddot{S}i^3,$$

induced me to propose a new name, *Aglaite* (Engineering and Mining Journal, April 7, 1877), but I have since inclined to the belief that the material is the same as that first studied by Shepard and Burton. It is therefore now presented as an independent species, under the original name, cymatolite, but it seems worth while to retain the name aglaite for application to the peculiarly brilliant and micaceous variety found at Goshen. In the coming volume of the Annals of the New York Academy of Sciences, I shall give a full discussion of the composition of this mineral, and of its interesting association with spodumene, killinite, œrstedite, autunite, etc.

ART. LI.—*The relations of the Volumes of Solutions of Hydrated Salts to their Water of Composition;* by RICHMOND J. SOUTHWORTH, M.D.

THE object of the experiments, the result of which is stated in the accompanying table, was to test this

Theorem: If a hydrated salt be dissolved in a given volume of water, the volume of the solution will exceed the original volume of the water by a bulk equal to the bulk of saline water contained in the salt dissolved.

The expression *saline water* is used here to signify all the molecules of water contained in the salts, whether they exist in combination as bases, or as water of crystallization. First, the weight in grams of the salt used that contained one cubic centimeter of water in its composition was determined by dividing the atomic weight of the salt by the atomic weight of its saline water, both weights being expressed in grams, the quotient gave the weight, having one cubic centimeter of saline water. As an example: Ferrous sulphate ($FeSO_4$, $7H_2O$) has an atomic weight of 278. Its 7 molecules of saline water have an atomic weight of 126. $\frac{278}{126}$ grams=2·206 the weight of this salt having one cubic centimeter of water in its composition.

Second: The quantity of salt determined by this method to contain one cubic centimeter of saline water was weighed to the nearest centigram, and the dissolved in 90 c.c. of water in a graduated tube of 100 c.c. capacity divided in one-half cubic centimeters. For instance, 2·20 grams of $FeSO_4$, $7H_2O$, were dissolved in 90 c.c. of water at the temperature of 15·5° Centigrade when the volume of the solution equalled 91 c.c.: 2·20 grams more of the salt were added to this solution, and the volume rose to 92 c.c. This process was continued till 22·06 grams of the salt, containing 10 c.c. H_2O, were dissolved in 90 c.c. of water, when the volume of the solution reached 100

c.c. In each of the steps, and in the final result, this experiment agreed with the theorem. This method was pursued where the first experiment with a salt showed a close agreement with the theorem. In those cases where there was a disagreement between the calculated volume and the observed volume of the solution, the weight of salt required to raise the volume of the solution one cubic centimeter was determined by direct experiment. For instance, barium chloride, with the formula ($BaCl_2.2H_2O$) by calculation contained one cubic centimeter of H_2O in 6·777 grams, but the quantity required to raise the volume of the solution one cubic centimeter was 3·89 grams. If the specimen of barium chloride used contained $4H_2O$, the experiment would give a result agreeing with the terms of the theorem.

Salt used.	By calculation.	By experiment.
$Na_2CO_3.10H_2O$	1·588	1·59
$Na_2SO_4.10H_2O$	1·788	1·63
$Na_2SO_4.H_2SO_4.3H_2O$	4·083	3·25
$Na_2O2B_2O_3.10H_2O$	2·122	2·12
$Na_2HPO_4.12H_2O$	1·591	1·59
$BaCl_2.2H_2O$	6·777	3·89
$SrCl_2.6H_2O$	2·468	2·47
$MgSO_4.7H_2O$	1·954	1·95
$ZnSO_4.7H_2O$	2·277	2·28
$NiSO_4.7H_2O$	2·228	2·23
$FeSO_4.7H_2O$	2·206	2·2
$CuSO_4.5H_2O$	2·771	2·77
$Al_2(SO_4)_3.18H_2O$	2·058	2·06
$AlK(SO_4)_2.12H_2O$	2·196	2·2
$AlNH_4(SO_4)_2.12H_2O$	2·099	2·1
$CrK(SO_4)_2.12H_2O$	2·31	2·31

The first column of the table gives the formulæ of the salts according to the last American edition of Fownes's Chemistry. The second column gives the weight in grams that contains one cubic centimeter of saline water, according to the formula. The third column gives the weight in grams found by experiment to increase the volume of the solution one cubic centimeter. An examination of the table will show a close agreement between the results of calculation and experimentation, with the exception of barium chloride, which has been referred to, and the acid sodium sulphate. The disagreement between the calculation and observation in this instance may possibly be explained by the salt decomposing in the act of dissolving, separating into sodium sulphate, which is dissolved, and hydrogen sulphate which unites with the water. This would agree with the strong acid reaction of the solution.

So far as the salts used in these experiments are concerned, the theorem stands the test of experiment, and is demonstrated to be true. In explanation of the changes that occur when a hydrated salt is dissolved in pure water, it may be assumed that the salt is decomposed, separating into an anhydrous portion and saline water, the former going into solution and the latter uniting with the solvent water, increasing its volume.

Yonkers, N. Y., Jan. 31st, 1879.

ART. LII.—*Analysis of the Tetrahedrite from Huallanca, Peru;* by W. J. COMSTOCK. Contributions from the Laboratory of the Sheffield Scientific School, No. LV.

IN this Journal for April, 1878, there is given a short extract from an article in the London Mining Journal by Mr. Henry Sewell, F.R.G.S., describing the mineral caves of Huallanca, Peru. Mr. Sewell states that these silver-producing caves are situated upon the eastern flank of the Peruvian Andes at an altitude of 14,700 feet above the sea, and 4000 feet above the town of Huallanca. The mass of the argentiferous ores consists of the mineral tetrahedrite; these ores contain about 800 ounces of silver to the ton. The mineral is in part obtained from huge cavities, some of them twenty-five or thirty feet long, and as much deep. Mr. Sewell describes the crystals as occurring in such abundance on the walls of these caves, that "millions" of them are destroyed by the picks of the miners.

Some specimens from this locality were presented to the Yale College Museum by Mr. Sewell; the crystals are large and brilliant and in one case have a length of about two inches. They have the usual characteristic tetrahedral form. I have analyzed a portion of one of the crystals, and have obtained the following results: Specific gravity =4·7.

	I.	II.	Mean.
S	26·69	26·79	26·74
Sb	9·08	9·04	9·06
As	13·35	13·62	13·49
Ag	3·95	3·77	3·86
Cu	39·01	39·16	39·09
Fe	5·46	....	5·46
Zn	2·14	....	2·14
	99·68		99·84

I give below the amount of sulphur required to combine with each of the metals and also the atomic ratio.

	Sulphur calculation.		Atomic ratio.	
Sb	3·56	S	·8356	·8356
As	8·57	Sb	·0743	·2528
Ag	·57	As	·1785	
Cu	9·87	Ag_2	·0179	·4567
Fe	3·12	Cu_2	·3083	
Zn	1·06	Fe	·0975	
		Zn	·0330	
	26·75			

From the above is obtained the ratio

$$\cdot 2528\ R_2S_3 + \cdot 9134\ RS, \quad \text{or} \quad R_2S_3 + 3 \cdot 6\ RS.$$

The method employed in the analyses was that of H. Rose, except in the determination of the arsenic. On account of the difficulty in weighing magnesium ammonium arseniate, after separating by means of magnesia mixture and alcohol the precipitate was dissolved in dilute hydrochloric acid, reduced by sulphurous acid, the excess of the latter was evaporated off, and the arsenic precipitated and weighed as sulphide. A slight amount of free sulphur was dissolved out by carbon-disulphide.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Determination of Fusing Points.*—Commonly fusing points are determined by placing a fragment of the substance in a thin glass tube attached to the bulb of the thermometer, and then placing both in water gradually heated until the substance melts, the temperature being then noted. Terreil proposes to modify this method by melting the substance separately and then by means of a glass rod a single drop is deposited on the thermometer bulb, which is then placed above a gas flame at such a distance that the heating is very slow. The temperature is read at the instant the substance melts, and the whole is allowed to cool and the solidifying point noted; this operation being repeated several times. In this method the phenomena of surfusion disappear, the fusing and solidifying points coinciding sensibly. For fusing points above 100° the thermometer should have a larger bulb, so that it changes temperature slowly.—*Bull. Soc. Ch.*, II, xxxi, 155, Feb. 1879. G. F. B.

2. *On Chromium, Manganese, Iron, Nickel and Cobalt Amalgams.*—Moissan has shown that when a concentrated solution of chromous chloride in water is agitated with a pasty sodium amalgam there is produced a chromium amalgam. After removal of the excess of sodium by boiling in water for an hour, the amalgam is obtained as a liquid, less fluid than mercury, covering itself on standing in the air with a black layer of oxide, decompos-

ing slowly in dry air, more rapidly in presence of water. Heated to above the boiling point of mercury in a current of hydrogen, it leaves a residue of metallic chromium, as a black amorphous mass, which heated on platinum foil becomes incandescent and leaves a residue of green chromic oxide. The chromium made by this process is not acted on by boiling concentrated sulphuric acid, but dissolves in dilute sulphuric acid and in strong nitric containing nitrous acid. Hydrochloric acid when hot attacks it slowly, evolving hydrogen. The amalgams of manganese, of cobalt, and of nickel which were obtained in this way have a pasty consistence and contain more of the metal than the chromium amalgam. Manganese amalgam was also obtained by electrolysis by decomposing a solution of manganous chloride, using a negative electrode of mercury. When distilled at 440° pulverulent manganese was obtained, which became incandescent when treated with a few drops of fuming nitric acid, and which decomposed water slowly at ordinary temperatures, rapidly at 100°. Since the production of this amalgam polarizes the electrodes, it is probable that the richness of the amalgam is definite for a given battery.—*Bull. Soc. Ch.*, II, xxxi, 149. G. F. B.

3. *On Chromates and Dichromates.*—Schulernd at Kolbe's suggestion, has examined the conditions under which dichromates of the metals are formed. He examined the salts formed with barium, lead, mercury, silver, thallium and lithium, using precipitation for their preparation in all but the latter case. With barium, lead, and mercury, only the normal chromate $R''CrO_4$, could be obtained, either by precipitating with potassium dichromate or by evaporating with excess of chromic acid. With silver, thallium and lithium on the other hand, dichromates were readily obtained. Silver nitrate is precipitated by potassium dichromate, yielding a dark red crystalline powder of silver dichromate, $Ag_2Cr_2O_7$. Thallous carbonate gives thallous chromate when precipitated by potassium chromate and thallous dichromate when thrown down by the dichromate in acid solutions. The chromate and dichromate of lithium are well crystallized salts, the former having a pure yellow, the latter a dark orange, almost black color. Each has two molecules of crystal water, both are deliquescent, and lose their crystal water at 130°.—*J. pr. Ch.*, II, xix, 36, Jan. 1879. G. F. B.

4. *On the Purification of Mercury.*—Brühl has proposed to use chromic acid for the purpose of purifying mercury, and has freed twenty-five kilograms of mercury from Wood's fusible metal with which it was contaminated, in two hours by its means. Five grams of potassium dichromate are dissolved in a liter of water, a few cubic centimeters of sulphuric acid are added, and the mercury is shaken with its own volume of the solution. The metal divides into small globules, a little red chromate being formed. The agitation is continued until this red powder has disappeared and the solution has become green. By a strong current of water, a gray powder of metallic oxides is washed away, and the process is re-

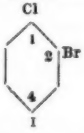
peated if necessary. The accumulated mercury of five years of the author's laboratory, some of which had been used to amalgamate zincs and was semi-solid, was completely purified in an afternoon in this way. The loss is small, two kilograms of mercury, after three treatments with 100 c.c. of the acid solution, washing, heating to 150° and weighing, lost only 10 grams.—*Ber. Berl. Chem. Ges.*, xii, 204, Feb. 1879. G. F. B.

5. *On Eikosylene, a hydrocarbon from the Paraffin of Brown coal.*—LIPPMANN and HAWLICZEK have examined the chlor-derivatives of paraffin from various sources, in order to determine the molecular weight of these bodies. In the first place, the paraffin of commerce was found uniformly to contain oxygen, from which it must be freed by repeated treatment with sodium in a sealed tube heated to 250°. Thus purified the brown-coal paraffin had, after recrystallization from alcohol, a melting point of 37° C. To produce the chloride it was at first treated with twice its weight of phosphoric chloride diluted with carbon tetrachloride, and heated in a sealed tube to 215°. But subsequently it was melted in a balloon at 170°, and the phosphoric chloride added as required through a wide tube, in the necessary quantity. The residue of the operation was liquid. After washing with water, it was separated from the unacted-on paraffin by cooling to —15° C. and fractionated in vacuo. An oily liquid was obtained in this way which boiled at 225° to 230° and afforded on analysis the formula $C_{20}H_{39}Cl$, having evidently been produced from the body $C_{20}H_{40}Cl_2$ by loss of HCl. Distillation at the ordinary pressure decomposed it further, $C_{20}H_{39}Cl = C_{20}H_{38} + HCl$. The hydrocarbon thus obtained boiled at 314°—315°, and the authors propose for it the name eikosylene. Its specific gravity is 0·8181, but its vapor density could not be determined, since it totally decomposed at 440°. It acts like an olefine, combining actively with halogens, forming a chloride $C_{20}H_{38}Cl_2$ and a corresponding bromide. It belongs to the acetylene series, being homologous with cetylene $C_{16}H_{30}$ its highest member. The evidence that the hydrocarbon $C_{20}H_{42}$, mixed perhaps with others of higher boiling point, constitutes the paraffin of brown coal, seems well established.—*Ber. Berl. Chem. Ges.*, xii, 69, Jan. 1879. G. F. B.

6. *On the Transformation of Starch into Dextrose in the Cold.*—It is known that starch is slowly transformed into dextrose when boiled for a long time with water. RIBAN has made some observations which seem to show that the same result may take place in the cold, though much more gradually. A solution made by boiling one part of finely divided starch in 100 of water saturated with salt, and filtering, is imputrescible and may be preserved for a long time. After a year the author's solution appeared less sensitive to iodine, and after three or four years, it was not colored by this reagent. It was neutral, limpid, contained no trace of any organized ferment, reduced energetically the copper test and was browned by alkalies. Determined by the copper test, every 100 c.c. contained 0·111 gram dextrose; but using ferricyanide of potas-

sium which is not affected by dextrin, 100 c.c. contained 0·102 gram. Hence a mixture of nine-tenths dextrose and one-tenth dextrin was formed from the starch. The solution, in a tube 200 mm. long rotated to the right; $a_D = +0·15°$. The author calls attention to the importance of this transformation of starch in the cold, without a ferment, in the physiology of vegetable growth.—*Bull. Soc. Ch.*, II, xxxi, 10, Jan. 1879. G. F. B.

7. *On the Structure-formulas of Aromatic Compounds.*—The present method of representing aromatic isomers is either graphic, by the use of the letters *p*, *m*, or *o*, standing for para, meta or ortho, or by using figures to represent the positions. Thus the structure of the compound C_6H_3ClBrI may be represented by



or by $C_6H_3{}^{1}Cl{}^{2}Br{}^{4}I$. Wroblevsky proposes a simpler mode of expressing the position of the replacing atoms, writing the formula differently according as the two replacing atoms are symmetrically or unsymmetrically arranged or occupy neighboring positions. Thus, for example, the chlorine derivatives of benzene may be written in this way so as to express all the facts in a much less space:

Empirical.	Symmetrical.	Unsymmetrical.	Neighboring.
$C_6H_4Cl_2$	$C_6H_2ClH_2Cl$	C_6H_3ClHCl	$C_6H_3Cl_2H$
$C_6H_3Cl_3$	$C_6HClHClHCl$	$C_6H_2ClHCl_2$	$C_6H_2Cl_3H$
$C_6H_2Cl_4$	$C_6HCl_2HCl_2$	$C_6HClHCl_3$	C_6HCl_4H

So if the positions 1, 2, 3, 4 in the benzene ring be filled by chlorine, bromine, iodine and hydrogen, the formulas will be $C_6H_2ClBrHI$, $C_6H_2BrClHI$, $C_6H_2IClHBr$, $C_6H_2BrIHCl$, $C_6H_2ClBrIH$, $C_6H_2BrClIH$, etc. In the first of these formulas the Cl is symmetrical with the I, is in the neighboring position with the Br, while the Br and I are unsymmetrically situated. So the naphthalene derivative which has I in the position 4 and Cl in 6, may be written $C_6HClH_2(C_4IH_2)$ or $C_6H_2ClH(C_4H_2I)$.—*Ber. Berl. Chem. Ges.*, xii, 161, Feb., 1879. G. F. B.

8. *On the Phthalein of Orthocresol.*—Fraude has extended the production of Baeyer's phthaleins by producing the phthalein of orthocresol $C_6H_4\begin{cases} CO\cdots C_6H_3\begin{cases} OH \\ CH_3 \end{cases} \\ CO\cdots C_6H_3\begin{cases} OH \\ CH_3 \end{cases} \end{cases}$. For this purpose two parts cresol, three of phthalic oxide and two parts of stannic chloride were heated together to 120° for 8 to 10 hours. The cresol unacted on was removed by a current of superheated steam, the mass was dissolved in solution of soda, and precipitated by hydrochloric acid, this process being repeated once or twice. Solution in alcohol, decolorization with bone black, and dilution with

water, gave the phthalein in flesh-red crusts. The diacetyl, dibenzoyl, dinitro, and dibrom derivatives are described, as also monoorthobromcresol-phthalein and its barium compound. By heating cresol and phthalic oxide with sulphuric acid, methyloxyanthraquinone is produced; and this heated to 200° C. with excess of potash yields methylalizarin. The phthalins, phthalidins and phthalideins corresponding to the phthaleins of orthocresol are described in the same memoir.—*Ber. Berl. Chem. Ges.*, xii, 237, Feb. 1879. G. F. B.

9. *Baryta and Strontia.*—The fact that the compounds of baryta and strontia occur in nature in very different associations has long been recognized by mineralogists, and in the December No. of the Ann. de Chim. et de Phys., M. Dieulafait has published an interesting paper which offers a plausible explanation of this difference of occurrence. In the first place the author established the fact that both baryta and strontia are present in sensible quantities in the feldspars and micas of the older crystalline rocks. He examined feldspars from fifty-four different localities, and also micas in numerous associations, besides eighty specimens of granites in mass, sixty of gneiss and many of syenite, and in all of these he discovered not only lime but also strontia and baryta. From various circumstances, but especially from the association of barite with metallic sulphides in mineral veins it is inferred that the alkaline earths are dissolved from the rocks as sulphides, and the author promises us in a future paper a discussion of the nature of the sulphuretted solvent. It is next argued, from the known reaction of the carbonic dioxide and oxygen of the atmosphere on a solution of strontic and baric sulphides, that such a solution while flowing off in contact with the air would deposit, in the first place, the carbonates of these bases nearest to the source, and, subsequently at a greater distance the sulphates, thus determining a separation between the two groups of minerals. Again the sulphate of strontia, being more soluble than the sulphate of baryta—and, according to the author, existing relatively in much larger quantities in the crystalline rocks—would be to a much greater extent washed down by the running streams; collecting in salt basins, and in the layers of gypsum, which are deposited in these basins; while on the other hand the more insoluble sulphate of baryta would be left behind. Lastly the strontium reduced from the condition of sulphate to sulphide by the organic matter in the gypsum beds—and thus becoming very soluble—again undergoes the same reactions in contact with the air to which we have just referred, giving rise first to an insoluble carbonate and a solution of a polysulphide and then to a sulphate and free sulphur. Thus are explained the facts that celestine is found almost always in beds of gypsum and associated with crystals of sulphur. It is argued in conclusion that if the circumstances of the occurrence of celestine and barite at the present day differ so widely that this arises solely from the fact that the strontium compounds found in salt-beds are in the second stage of their development, while the corresponding

compounds of baryta left in the veins of crystalline rocks are in the first stage; and that in spite of all present differences of occurrence and association, the baryta and strontia minerals may be traced to the same origin in the old crystalline rocks of the earth's crust. J. P. C.

11. *The illumination of gases by Electric discharges.*—Professor E. WIEDEMANN continues his work upon the nature of spectra, and shows that a gas having a temperature far below 100° C. can be illuminated by electrical discharges. By means of a small calorimeter, in connection with a peculiarly arranged exhaustion tube, Professor Wiedemann was enabled to arrive at the amount of heat communicated to the gas under examination at different pressures. The temperature of the gas in the beginning was in the neighborhood of 20° C. and reached a maximum of from 80°–90° by means of the discharges from a Ruhmkorf coil, even at this temperature the gas was brilliantly illuminated; and the temperatures of 62°–70° was not found to be the lowest at which the gas was illuminated.

The illumination of the gas at such low temperatures is produced, Professor Wiedemann thinks, by an exaltation of the living force of the oscillatory movements of the ether envelopes. The electrical discharge calls forth this action independently of the increase of molecular movement which results from the increase of temperature.—*Annalen der Physik und Chemie*, No. 2, 1879, p. 298. J. T.

12. *A new current interrupter.*—Dr. F. NIEMOLLER describes an extremely simple and efficacious form of interrupter. To the middle of a wire stretched horizontally is attached a platinum point which touches the surface of mercury in a little containing vessel. The current is led over this wire, and a magnet over the half of the wire through which the current is conducted serves to maintain the vibrations of the wire. The number of vibrations can be readily modified by changing the length of the wire, and as high a number as 1000 breaks in a second can be obtained. By passing an intermittent current over the wire it can be set in vibration without the intervention of mechanical means. This happens when the fundamental note of the string is in unison with the pitch of the interrupter.—*Annalen der Physik und Chemie*, No. 2, 1879, p. 302. J. T.

13. *The dimensions of Molecules.*—R. RÜHLMANN, by means of the formula

$$\lambda = \frac{1}{\sqrt{2}} \frac{\delta^3}{\pi\rho^2},$$

in which λ represents the mean path of the molecules, δ the mean distance between the molecules and ρ the radius of their sphere of action, calculates the sum of the molecular sections. Since $N\delta^3=1$, if N represents the number of molecules in the unit of volume, we have

$$\frac{N\rho^2\pi}{4} = \frac{1}{4\sqrt{2}\lambda}$$

According to Avogadro's law equal volumes of different gases under the same pressure and temperature contain the same number of molecules, the ratio of the sum of the sections is the ratio of the section of the molecules themselves. Bearing this in mind, one is justified, since the mean accuracy of the numbers found can be depended upon within eight per cent, in regarding, in the following tables, the numbers found for the two-atom molecules, with the exception of chlorine, hydrogen and hydrochlorine, as equal among themselves, and the section of the hydrogen molecules as one-half and that of chlorine as twice as great. The three-atom molecules of CO_2, of N_2O, of H_2O and of H_2S have the same molecular sections and stand in relation to the large number of two-atom gases as 3 : 2 or as the number of atoms. To this law SO_2 is an exception, since its molecular section is the same as that of chlorine. H_3N and HCl take a decided position. Possibly CH_4 can be included with them, since the mean of these three numbers is related to the molecular section of the two-atom molecule nearly as 4 : 3. One is also tempted to regard the molecular sections of C_2H_4, of SO_2, of chlorine, and CH_3Cl as equal and as double that of the two-atom molecule.

The following table includes the sum of the molecular sections of each gas in a cubic centimeter, expressed in square centimeters.

	H_2	9100	approximately	9000	$= 1 \times 9000$
Two-atom	O_2	16900	"	18000	$= 2 \times 9000$
	N_2	18000	"	18000	
	CO	18200	"	18000	
	NO	18700	"	18000	
Three-atom	CO_2	26700	"	27000	$= 3 \times 9000$
	N_2O	26800	"	27000	
	H_2O	26400	"	27000	
	H_2S	28600	"	27000	
	CH_4	21600	"	24000	$= \frac{8}{3} \times 9000$
	H_3N	23400	"	24000	
	HCl	24200	"	24000	
	C_2H_4	31600	"	36000	$= 4 \times 9000$
	SO_2	36700	"	36000	
	Cl_2	36700	"	36000	
	CH_3Cl	39300	"	36000	

Professor Rühlmann also gives the following values of ρ.

For nitrogen molecule $= 34 \cdot 10^{-9}$ cm.
For carbonic dioxide molecule $= 16 \cdot 10^{-9}$ cm.
For hydrogen molecule $= 41 \cdot 10^{-9}$ cm.

At 0° and 760 mm. pressure a cubic centimeter holds nearly 100 trillions of gas molecules. Under these conditions the molecules themselves fill nearly the three-thousandth part of the space occupied by the gas. The absolute weight of a hydrogen molecule is represented by $15 \cdot 10^{-23} g$ and the specific weight as 360.—*Beiblätter Annalen der Physik und Chemie*, 1879, No. 2, p. 57.

J. T.

14. *American Chemical Journal;* edited, with the aid of Chemists at home and abroad, by IRA REMSEN, Professor of Chemistry in the Johns Hopkins University. Vol. i, No. 1, 76 pp. 8vo. Baltimore, April, 1879.—The establishment of this American Chemical Journal is an event of great importance to the science of the country. The Journal could not be in better hands; for the editor, Professor Remsen, is both a man of thorough learning in his department, and an able and hard-working investigator. The number just issued compares well in its memoirs with the best of other lands. The subjects of some of these are: the Complex inorganic acids, by Wolcott Gibbs; Nitrogen iodide, by J. W. Mallet; on Lockyer's hypothesis that the so-called Elements are compound bodies, by C. S. Hastings; a New Volumetric method of determining Fluorine, by S. L. Penfield; on the Oxidation of substitution-products of aromatic Hydrocarbons, by Ira Remsen and M. W. Iles. The Journal is to be issued every other month; the subscription price is three dollars a year.

II. GEOLOGY AND NATURAL HISTORY.

1. *Fossil Forests of the Volcanic Tertiary Formations of the Yellowstone National Park;* by W. H. HOLMES. (Bull. U. S. Geol. and Geogr. Survey, Vol. v, No. 1.)—The volcanic Tertiary deposits (tufas, etc.) of the Yellowstone region have a thickness of more than 5,000 feet. They contain silicified trunks of trees in many places. Mr. Holmes describes particularly a section on the north face of Amethyst Mountain, in which upright trunks occur at many levels, along with others prostrate, from near the foot to the highest stratum. On the steeper part "rows of upright trunks stand out like the columns of a ruined temple," and on the slopes lower down, the petrified trunks fairly cover the surface. Some of the prostrate trunks are fifty to sixty feet long and many are five to six feet in diameter. The upright trunks are occasionally thirty feet high; and one twelve feet high was ten in diameter, and its bark was four inches in thickness. There are also leaves and stems, and Lesquereux has identified among them *Aralia Whitneyi*, *Magnolia lanceolata*, *Laurus Canariensis*, and new species of *Tilia*, *Fraxinus*, *Diospyros*, *Cornus*, *Pteris* and *Alnus*.

2. *Fruit-bearing branch of Cordaites from Cannelton, Pennsylvania.*—In the Proceedings of the American Philosophical Society for April, Professor Lesquereux has described a specimen of Cordaites bearing fruit, collected by Mr. I. F. Mansfield at Cannelton. It is a bent or pendent branch twelve centimeters long and nearly one and a half broad, having the fruit arranged spirally in a loose strobile-like way. The winged nut or fruit is oval, 3 centimeters long, 2·3 broad, and broadly obtuse and entire at top. It indicates, according to Mr. Lesquereux, that the Cordaites are allied to the Cycads, or rather are an antecedent type intermediate between Cycads and Conifers.

3. *Annual Report of the Wisconsin Geological Survey, for the year* 1878; by T. C. CHAMBERLIN, Chief Geologist. 52 pp. 8vo. Madison, Wis., 1879.—This Report contains observations on the recent glacial drift of the Alps, and on the bearing of the facts on Wisconsin surface geology, by Professor Chamberlin.

4. *The Woodland Caribou or Reindeer* (*Rangifer Caribou*) *from the Loess of Iowa.*—Dr. LEIDY announces the discovery by Professor Witter, in the lœss of Muscatine, Iowa, of fragments of the upper and lower jaws and some other bones of this species. From the same locality Professor Witter collected the shells *Helix striatella*, *H. fulva*, *H. pulchella*, *H. lineata*, *Pupa muscorum*, *P. Blandi*, *P. simplex*, *Succinea obliqua*, *S. avara*, *Limnea pumilis?* and *Helicina occulta.*—*Proc. Acad. Nat. Sci. Philad.*, 1879, p. 32.

5. *Amber and Asphaltum from Vincenttown, New Jersey.*—Mr. E. GOLDSMITH reports these minerals from the Ash Marl of the Cretaceous, a layer above the Green-sand. The mass of asphaltum weighed 100 pounds. The amber is stated to be related to the variety of succinite called Krantzite by C. Bergemann. Unlike ordinary amber its specific gravity is less than 1, and it fuses to a mobile liquid. This amber is of occasional occurrence in the New Jersey Cretaceous; "sometimes hundreds of tons may be looked over without finding a single piece; and at other times enough has been found to fill a barrel within a day."—*Ibid.*

6. *Guides for Science-Teaching.* — This is the title of a few primers, published by the Boston Natural History Society, and meant to supplement and enforce lectures given by members of that Society to Teachers of the Public Schools of Boston. These teachers are all required to give to their pupils a certain number of *object lectures.* But who shall teach the teachers, and wherewithal shall they be taught? Well, a few public-spirited ladies supplied the material means for a free course of instruction to five or six hundred teachers, and two or three individuals contributed their knowledge and experience, and carried into execution an admirable plan. The substance of the lessons of this course, given by Mr. Hyatt and Professor Goodale, is exhibited and preserved in these primers. The plan was to speak of nothing which was not shown, and not only shown but placed in the hands of the auditors. And this not by specimens passed round, and so reaching most of the pupils after the discourse had passed on to something else; but each hearer was supplied with a whole suite of the objects lectured on, to examine at the moment and to take home for further examination and review.

The first lesson, by Mr. Hyatt, is *About Pebbles.* A tray placed before each pupil holds a small quantity of fresh-broken rock, a weathered piece with worn angles, a complete and rounded pebble, a spoonful of gravel and another of sand. With these, and with reference to what every one remembers to have seen on shores and beaches, in quarries and stone-yards, and along brooks and roadsides, the lesson proceeds, and the elemental facts are

taught rather by questions asked and by observations incited than by didactic lecturing.

The second primer contains the substance and displays the method of Professor Goodale's course of lessons "*Concerning a Few Common Plants.*" For the first lesson, on a seedling, each of the five hundred auditors, supposed normally to represent a child-pupil, had before him a bean freshly soaked, another the sprouting of which in germination had barely commenced, a third with germination more advanced, a fourth which had developed not only a root below, but the first two leaves above the cotyledons. The discourse opens by the asking of some simple questions, every one of which must be answered by an examination of these objects. The second lesson compares two seedlings, viz. the pea with the bean; the third compares still other and different seedlings; and by this time the pupils have made out the leading facts and ideas of vegetable morphology as it were for themselves. This knowledge is extended in a similar way, and by the comparison of various leafy shoots, to the consideration of "how the parts of plants help one another." Later these parts, roots, stems, and leaves are taken up separately; then the way in which plants feed and grow is taught; then wood is illustrated by small truncheons, blocks variously cut, and veneers, of which each pupil has a set; and the structure and morphology of the blossom is brought out by similar methods. Teachers so taught should be able to give "object lessons" to their young pupils with some success. Those who have not the advantage of such training should send for these primers (costing ten and twenty cents apiece) study them thoroughly, and follow the directions they give.

The third primer, about Commercial and other Sponges, is very good, but different. It begins aright with a bath sponge, and some common reef-sponges to be had cheaply of the wholesale druggists. But it departs from the normal plan by entering into microscopic details, illustrated by figures, and into an account of sponge-gathering by divers in the Mediterranean and the Gulf of Mexico. A. G.

7. *Function of the Sterile Filament of Pentstemon.*—Dr. Léo Errera, in Belgium, has been investigating two allied Mexican species, viz. *Pentstemon gentianoides* and *P. Hartwegi*, with their varieties, now common in cultivation. Noting the fact that the sterile filament, which belongs to the upper side of the flower, is from near its base, declined upon the lower side of the corolla-tube or throat, he comes to the conclusion that its principal function is to obstruct the access of unwelcome insects to the nectar at the base of the flower. The size of the corolla and disposition of the genitalia is such that only large insects, such as humble bees, which fill the whole cavity, can effect fecundation. The somewhat smaller ones, which would rifle the flower of its sweets without rendering any service, are excluded from the nectar by this bar across the base of the tube. Professor Kerner,

who of late has especially studied the arrangements in flowers for the exclusion of unbidden guests, as he terms them, appears to have anticipated this conclusion in respect to *Pentstemon*. While making observations upon the five forms of these two species which were in cultivation at Brussels, Dr. Errera was surprised to find that only one of them was freely visited by hymenopterous insects: this was a form of *P. Hartwegi*, with mauve-colored corolla. The others, though occasionally tried, were, on the whole, neglected; and he found that this remarkable preference depended not at all upon the abundance or quality of the nectar, nor upon the perfume, nor upon the color of the corolla, except by a coincidence as to the latter; but in the fact, that in all but the mauve-colored form, the curvature of the sterile filament, which obstructed further entrance, was so high in the tube that the tongue of these insects could not reach the nectar at the bottom of the tube. A difference of a millimeter or two in the curvature of the sterile filament or the length of the tube below, determined whether or not the flowers should be fertilized in Belgium.

Errera's paper is published in the 17th volume of the *Bulletin de la Société Royale de Botanique de Belgique*, February, 1879, is preceded by a very detailed dissertation on the structure and fecundation of flowers in general, by himself and M. Gustave Gevaert, occupying 140 pages, 8vo. The motto of the paper is taken from Darwin—"Whoever is led to believe that species are mutable, will do good service by conscientiously expressing his conviction." The authors have expressed theirs, and the grounds of it, with great fullness. A. G.

8. *Revue Mycologique*, is the title of a new periodical, devoted to the study of *Fungi*, under the editorship of M. Roumeguère of Toulouse, published at that city and at Paris (Baillière); the first number, of 44 pages, 8vo, issued in January last. Price 12 francs a year. The leading article is upon the Lichen question, in the light of the recent investigations of Dr. Minks, confirmed by Dr. Mueller of Geneva. Half of this first fasciculus is devoted to notices of recent publications and to mycological news. The editor takes notice of Professor Hitchcock's recent proposition to the microscopists in the convention at Indianapolis, to adopt the $\frac{1}{100}$ of a millimeter as the micrometric unit, and regrets it, on account of the adoption, several years ago, in Europe (upon the proposition of Suringar of Leyden) of the $\frac{1}{1000}$ of a millimeter (denoted by the Greek μ) as the micrometric unit. A. G.

9. *Meehan's Native Flowers and Ferns of the United States*, illustrated by chromolithographs of Prang & Co.—The whole of vol. ii, issued since our last notice, is now before us. The new volume, parts 13 to 24, compares very favorably with the first. The drawings are better; the color-printing at least as good; and the excursions in the letter-press comparatively seldom tempt the reviewer to critical remarks. Such plates as those of *Phaseolus diversifolius*, *Andromeda Mariana*, *Cerastium arvense*, *Helianthus Maximiliana*, and *Echinocatus polycephalus*, even satisfy the

fastidious. Perhaps we should have added *Gaillardia amblyodon* to the list, if we had not placed by the side of it Sprague's figure in the Chloris Bor.-Am., which belongs to some of this artist's early work. We could wish that Meadow Beauty (*Rhexia Virginica*) had a better opportunity to display her charms. We learn that the work will be directly continued in a second series, in which we hope that the success of the enterprise will stimulate still further improvement in the drawings. A. G.

10. *Observations on Several Forms of Saprolegnieæ;* by FRANK B. HINE, B.S.—This is a thesis, submitted for the degree of B.S., at Cornell University, and the pamphlet is an article extracted from the American Quarterly Microscopic Journal, vol. i. It is illustrated by four excellent plates, drawn by the author from nature. The figures and the letter press (20 pages) give a very favorable impression of the author's ability, judgment, and taste. The two latter qualities are shown in his forbearance to give new specific names to forms of which the sexual reproduction is not made out, notwithstanding their apparent difference from described species; and he refrains from proposing a new genus in another case upon a new point of structure which he observed, but which may not require or justify this distinction. An indisposition to introduce new names which may be needless, and therefore encumbering, is a hopeful sign. A. G.

11. *A Popular California Flora, or Manual of Botany for Beginners;* by VOLNEY RATTAN, Teacher of Natural Sciences in the Girls' High School, San Francisco. (S. Francisco: Bancroft & Co. 1879).—The schools of California have long been needing an aid like this by which they may study the flowers which abound around them, and which in spring make gay the whole face of the country. This book, of 103 pages, in the form of "How Plants Grow," is the first and a laudable attempt to supply a pressing want. It is a first part only, including the Polypetalæ and Gamopetalæ, and a second part will complete the work. It is very well compiled from the Botany of California and the Synoptical Flora of North America; and it is restricted to the plants of the San Francisco region, extending north to Mendocino County, south to Monterey, and west to the foot-hills of the Sierra Nevada. The *Umbelliferæ* and *Compositæ* are omitted because "too difficult for beginners." In a second edition these might be added, and rendered about as easy as the rest, with a skillful popular presentation, for which we could give the worthy author some hints. A. G.

12. *Halosphæra, eine neue Gattung grüner Algen aus dem Mittelmeer;* by Dr. FR. SCHMITZ.—The present paper, taken from the first volume of Mittheil. aus der Zoologischen Station at Naples, gives an account of a minute floating Alga, which is common in the Bay of Naples from January to April, and is vulgarly known as "punti verdi." Pelagic Algæ are little known, and the present species offers several points of interest. It occurs in the form of isolated spherical cells which float on the open sea, without any independent power of locomotion. The cell-contents divide into very numerous daughter-cells which produce zoöspores

by secondary division. The latter are of an unusual form, being conical, with the two long cilia attached to the base instead of to the apex of the cone. The development of the zoöspores is unknown.

In this connection we may mention a second paper by the same author on *The Green Algæ of the Bay of Athens.* He considers the little known *Acrocladus mediterraneus* of Nægeli to be merely a peculiar condition of the common *Cladophora pellucida* of Kützing, and not the young of *Acetabularia*, as was supposed by Zanardini. He describes two new species of *Siphonocladus*, a genus midway between *Valonia* and *Cladophora*, resembling the latter in ramification but differing from it in the transverse cell-walls not being complete, but only partial as in *Valonia.* At the end of the paper are some remarks on the relations of different genera of green Algæ, which constitute the *Siphonocladiaceæ.*

G. W. F.

13. Dr. W. G. Farlow, for the past five years Assistant Professor of Botany at the Bussey Institution, Harvard University, has been appointed Professor of Cryptogamic Botany in the University proper. This is the first professorship in this important and difficult department established in this country. The laboratory for instruction and research in the lower Cryptogamia is now established at Cambridge.

III. Miscellaneous Scientific Intelligence.

1. *Intra-Mercurial Planet.*—Careful search was made at the Royal Observatory, Greenwich, and other places for the transit of the supposed intra-Mercurial planet over the Sun, which, according to an orbit calculated by Dr. Oppolzer, of Vienna, might take place in the morning of the 19th of March last. Nothing, however, was seen of it—a result which cannot surprise those accustomed to astronomical observations, and able to appreciate the great uncertainty of the data on which the calculations were founded, several of the observations (among which we, for our part at least, must include the famous one by the Orgères physician, M. Lescarbault, in 1859) being probably of some spot on the Sun or else altogether apocryphal. With regard to the objects seen during the total solar eclipse last July, Dr. Oppolzer's orbit did not take in either of them.—*Athenæum*, April 12.

2. *Geological Society of London.*—At the recent annual meeting of the Geological Society, the Wollaston gold medal was awarded to Professor Bernard Studer, "the father of Swiss geology;" the Murchison medal to Professor M'Coy, of Melbourne; the Lyell medal to Professor E. Hébert, of Paris; the Bigsby medal to Professor E. D. Cope, of Philadelphia; the balance of the Wollaston Donation Fund to Mr. Samuel Allport; the proceeds of the Murchison Geological Fund to Mr. J. W. Kirkby; a moiety of the balance of the proceeds of the Lyell Fund to Professor Alleyne Nicholson, and the other moiety to Dr. Henry Woodward, F.R.S. —*Nature*, March 13.

3. *Geological Survey of the Territories of the United States.*—The plan proposed by the Committee of the National Academy of Sciences for the scientific surveys of the United States Territories (this Journal, January, 1879, p. 78), was accepted by Congress, just at the close of the last Session, (March 9th), so far as it relates to the Geological Survey. The position of Director of the Survey has been given to Mr. Clarence King, who has recently brought the Survey of the 40th Parallel to a successful completion. Congress has also appropriated a sum of twenty thousand dollars for the final completion of each of the three Surveys, which have been carried on up to this time under Lieut. Wheeler, Dr. F. V. Hayden, and Major Powell.

4. *Gold Medal of the Astronomical Society.*—The Council of the Royal Astronomical Society of England has awarded the gold medal of the society for this year to Professor Asaph Hall of Washington. In the address of the President, Lord Lindsay, on presenting the medal, a detailed statement is made of Professor Hall's many and valuable contributions to astronomical science, with special reference to the most important of these: the discovery of the satellites of the planet Mars.

5. *Paris Academy of Sciences.*—The "Serres" Prize for 1878 has been awarded by the Academy of Sciences, for the best work in embryology, to ALEXANDER AGASSIZ, of Cambridge. This is the first time the prize has been given. The value of the prize is 7500 francs.

Prof. J. Lawrence Smith has recently been elected a Corresponding Member of the Academy, in the place of Sir Charles Lyell.

6. *Memoirs of the Museum of Comparative Zoology.* — The first part of No. 1, vol. vi, of the Memoirs of the Museum of Comparative Zoology at Cambridge, Mass., has just been published. It contains a portion (288 pp.) of a work on the Auriferous Gravels of the Sierra Nevada of California, by Professor J. D. Whitney. The remainder of the volume will be ready in a few months.

7. *Report of the Observations of the Total Solar Eclipse, July 29th, 1878, made at Fort Worth, Texas;* edited by LEONARD WALDO, Assistant of the Observatory of Harvard College. 60 pp. 4to, with 4 plates. Cambridge, 1879.—A notice of this report will be given in another number.

OBITUARY.

FRANK HOWE BRADLEY died, from the falling of a bank in a gold mine, near Nacoochee, Georgia, on the 27th of March. Mr. Bradley was born at New Haven, Connecticut, on the 20th of September, 1838. He was graduated at Yale in 1863, and afterward pursued special studies in natural science in connection with the Sheffield Scientific School. But still earlier, his tastes had led him to the study of geology, and in 1857, before he had passed his nineteenth birthday, he had by his discoveries at Keeseville added a new trilobite to the known fauna of the New York Potsdam sandstone, which till then had afforded no animal remains

but Lingulæ and Scolithi; and had proved by imperfect specimens the existence also of Crinoids and Pleurotomariæ in the same beds. This discovery was announced that year at the meeting of the American Association at Montreal, and made the subject of an article in this Journal in 1860. After his graduation at Yale, much of his time was spent in the field making collections of fossils, and, for more than a year, at Panama and its vicinity where he obtained large collections of corals and other specimens in zoology, partly for the Yale Zoological Museum. During the year 1867 he was assistant geologist in the survey of Illinois, and, in 1869, in that of Indiana. The Indiana report for that year contains a valuable chapter by him, treating especially of the Vermilion County Carboniferous rocks. Two species of land snails from these rocks were described by him in this Journal, in 1872. During the summer of that year he was assistant geologist in the geological survey of the Territories under Dr. F. V. Hayden, and among his important results, as set forth in his excellent report, there is the identification by fossils of the Quebec group in Idaho, and also at the base of the Archæan Teton range. During the years 1869 to 1875, Mr. Bradley was Professor of Geology and Mineralogy in the University of Tennessee; and while there he made a detailed section of the unaltered Lower Silurian formations and the continuation of the beds in crystalline rocks on the east; and the results of his careful work are embodied in a communication to this Journal in 1876 "on the Silurian age of the Southern Appalachians." During the same year he prepared, and in 1876 published, a valuable, though small, geological map of the United States.

Professor Bradley left his position at Knoxville in 1875, with the hope of so adding to his resources, that he might be able to pursue his favorite science untrammeled by outside obligations; and it was in laboring toward this end, but before his expectations had been realized, that he met with his untimely death.

Professor Bradley was a man of profound zeal for science, of exactness in observation, of great energy, and of independent judgment and purpose. His tall, straight figure, neatly dressed, but after a fashion dictated by his work and not by prevalent modes, exhibited his independence of character no less than his strongly drawn physiognomy. His lines of action were laid down by his sense of what was right and just, and once fixed, even if bearing only on the position of a comma in a proof sheet, there was no swerving. He even contemned any accommodation to circumstances in order to avoid friction, and met with more of this than he need have encountered. But he was a man of real kindness of heart, of warm friendships, and of great uprightness.

Professor Bradley was married to Miss Sarah M. Bolles of New Haven, in 1867. He leaves a wife and one young daughter, an infant child having died on the day of his own death. J. D. D.

Dove, the eminent professor of Physical Geography at Berlin, died on the 6th of April, at the age of seventy-seven.

W. K. Clifford, of University College, London, an able mathematician, died at Madeira, early in March.